SCIENCE

NEW SERIES. VOL. VI. No. 143. FRIDAY, SEPTEMBER 24, 1897. SINGLE COPIES, 15 CTS. ANNUAL SUBSCRIPTION, $5.00.

The Volcanoes of North America.

By ISRAEL C. RUSSEL,
Professor in the University of Michigan.

Cloth, 8vo. Just Ready. Price, $4.00 *net*.

A work, which taken together with Sir Archibald Geikie's comprehensive volumes on the Ancient Volcanoes of Great Britain, places in the hands of scientists adequate reference works on all branches of this important subject.

Elementary Geology.

By RALPH S. TARR, F. G. S. A.,
Professor of Dynamic Geology and Physical Geography at Cornell University, formerly an Instructor in Harvard University, author of "Economic Geology of the United States," etc.

12mo, cloth. Price, $1.40 *net*.

Intended for High School Use, giving in combination with the "Elementary Physical Geography," by the same author, an excellent foundation for the study of the natural sciences.

An Introduction to Geology.

By WM. B. SCOTT,
Professor of Geology and Palæontology, Princeton University.

12mo, cloth, pp. 570. Price, $1.90 *net*.

An admirable general view of the subject, for those who wish to lay a reliable, fairly proportioned foundation for later specialization, and for those who do not expect to do further work along these lines, yet wish that knowledge of the fundamental principles of the science essential to very good education.

Rocks, Rock-Weathering, and Soils.

By GEORGE P. MERRILL,
Curator of the Department of Geology, United States National Museum, and Professor of Geology in the Corcoran Scientific School and Graduate School of the Columbian University.

Fully Illustrated. 8vo, $4.00 *net*.

Dr. Merrill has taken up a hitherto much neglected line of work, and one which on both economic and scientific grounds is of the greatest interest and importance. He treats of the origin, composition, and structure of the rocks composing the earth's crust, the manner of their weathering, or breaking down, and the causes that lead thereto, and finally of the petrographic nature of the product of this breaking down.

The matter is so arranged that the book will be of value as a work of reference, and also as a text-book for students in the Agricultural Colleges and Experimental Stations, while teachers and students in general geology or physiography will find it to contain much of interest.

The Rural Science Series.

Books which state the underlying principles of agriculture in such language that they may be read at the home fireside, in the office, at the club or grange, or used as text-books. Each is substantially bound in blue cloth.

The Soil:

Its Nature, Relations, and Fundamental Principles of Management.

By F. H. KING,
Professor of Agricultural Physics in the University of Wisconsin.

303 pages, 45 Illustrations. Price, 75 cents.

"I consider it a most desirable addition to our agricultural literature, and a distinct advance over previous treatises on the same subject, not only for popular use, but also for students and specialists, who will find many new and useful suggestions therein."

E. W. HILGARD,
Director of Agricultural Experiment Station,
Berkeley, Cal.

The Fertility of the Land:

A Summary Sketch of the Relationship of Farm-Practice to the Maintaining and Increasing of the Productivity of the Soil.

By I. P. ROBERTS,
Director of the College of Agriculture, Cornell University.

Fully Illustrated. Cloth. Price, $1.25.

This is a companion to Professor King's book, treating the subject from the standpoint of the actual farmer, rather than that of the laboratory. It is the only book which treats the philosophy of farm-practice in a modern way. The book is the result of a long life of teaching, experimenting and farming, and is the most important single book of farming methods which the farmer can secure.

THE MACMILLAN COMPANY, 66 Fifth Avenue, New York City.

Scientific Apparatus

"BOWDOIN" X-RAY FOCUS TUBE.

My Specialties Are:

"W-S" X-Ray Apparatus; Weston Ammeters, Voltmeters and Wattmeters; "Chlorid Accumulator" Storage Batteries; Electrical Measuring Instruments; Physical and Optical Apparatus; Pyschological Apparatus, etc.

"Duty Free" Importations from all prominent European makers.

Correspondence requested.

JAMES G. BIDDLE,

Dealer, Manufacturer's Agent and Importer,

909 Drexel Building, PHILADELPHIA.

Dec. 1, 1896. Just Published. Sixth Edition of

THE MICROSCOPE AND MICROSCOPICAL METHODS,

By **SIMON HENRY GAGE**, Professor of Microscopy, Histology and Embryology in Cornell University and the New York State Veterinary College, Ithaca, N. Y., U.S A. Sixth edition, rewritten, greatly enlarged, and illustrated by 165 figures in the text. Price, **$1.50**, postpaid.

COMSTOCK PUBLISHING CO., Ithaca, N. Y.

Cambrian Fossils. A large collection of Upper Mississippi Cambrian fossils from the St. Croix (Potsdam) sandstone for sale. Mostly Trilobites. Send for low prices.

W. A. FINKELNBURG, WINONA, MINN.

NEW CATALOGUE.

We have recently issued a new edition, revised and enlarged to 64 pages, of our catalogue of

Books on Chemistry, Chemical Technology and Physics.

It is arranged by subjects, and includes all the standard books in Chemical and Physical Science, as well as the recent literature up to date.

A copy of this Catalogue will be sent free by mail to any address.

D. Van Nostrand Company,

Publishers and Importers of Scientific Books,

23 Murray St. and 27 Warren St., New York.

Exhaustion

Horsford's Acid Phosphate.

Overworked men and women, the nervous, weak and debilitated, will find in the Acid Phosphate a most agreeable, grateful and harmless stimulant, giving renewed strength and vigor to the entire system.

Dr. Edwin F. Vose, Portland, Me., says: "I have used it in my own case when suffering from nervous exhaustion, with gratifying results. I have prescribed it for many of the various forms of nervous debility, and it has never failed to do good."

Descriptive pamphlet free on application to
Rumford Chemical Works, Providence, R. I.
Beware of Substitutes and Imitations.

For sale by all Druggists.

For 12 Cents

I will mail a finely finished original photo, cabinet size, of **Sioux Indian Chief, SITTING BULL, with his Signature.** Have 200 subjects, all different, of leading Western Indians. First-class work. Cabinet Size for 10 cents each. Some sent on selection. Give reference. After seeing sample you will want others. Indian Costume, Ornaments and Weapons. 15,000 Flint Stone Ancient Indian Relics. 100,000 Mineral and Fossil Specimens. Catalogue for stamp. 13th year.

L. W. STILWELL, Deadwood, South Dak.

HOUGH'S "AMERICAN WOODS"

A publication illustrated by *actual specimens.*

WOODS FOR THE STEREOPTICON

Enabling you to show upon the screen characteristic structures projected from nature itself.

WOODS FOR THE MICROSCOPE

Sections 1-1200 in. thick showing three distinct views of grain under each cover glass.

WOOD SPECIMENS FOR CLASS USE

Nothing equals these for use in the class-room.

VIEWS OF TYPICAL TREES

From Nature, photographs and stereopticon views.

WOODEN CROSS-SECTION CARDS

Perfectly adapted to printing (with type or steel plate), painting, India ink work, etc.

If you are interested in wood or trees in any way send for our circulars and sample specimens.

Address R. B. HOUGH, Lowville, N. Y.

SCIENCE

EDITORIAL COMMITTEE: S. NEWCOMB, Mathematics; R. S. WOODWARD, Mechanics; E. C. PICKERING, Astronomy; T. C. MENDENHALL, Physics; R. H. THURSTON, Engineering; IRA REMSEN, Chemistry; J. LE CONTE, Geology; W. M. DAVIS, Physiography; O. C. MARSH, Paleontology; W. K. BROOKS, C. HART MERRIAM, Zoology; S. H. SCUDDER, Entomology; C. E. BESSEY, N. L. BRITTON, Botany; HENRY F. OSBORN, General Biology; C. S. MINOT, Embryology, Histology; H. P. BOWDITCH, Physiology; J. S. BILLINGS, Hygiene; J. MCKEEN CATTELL, Psychology; DANIEL G. BRINTON, J. W. POWELL, Anthropology.

FRIDAY, SEPTEMBER 24, 1897.

CONTENTS:

The Groundwork of Dynamics: JOHN GALBRAITH..457

Mathematics and Physics at the British Association: HUGH L. CALLENDAR.....464

The Botany of the British Association: D. P. P....472

Marine Biological Laboratory.....475

A New Laboratory Dish: W. M. L. COPLIN.....476

Notes on Inorganic Chemistry: J. L. H.....478

Scientific Notes and News:—
Meeting of the Trustees of the Marine Biological Laboratory; The Johns Hopkins Biological Station in Jamaica; The Conference on the Seal Fisheries; General.....479

University and Educational News.....485

Discussion and Correspondence:—
Types in Natural History and Nomenclature of Rodents: OLDFIELD THOMAS. *Marriage by Capture in Arabia:* EDWARD S. HOLDEN.....485

Scientific Literature:—
Russell on the Foundations of Geometry: GEORGE BRUCE HALSTED. *Le Conte on Sight:* J. MCKEEN CATTELL.....487

MSS. intended for publication and books, etc., intended for review should be sent to the responsible editor, Prof. J. McKeen Cattell, Garrison-on-Hudson, N. Y.

THE GROUNDWORK OF DYNAMICS.*

THE subject of dynamics is too often treated as if its chief value consisted in the opportunities it affords for familiarizing the student with the operations of the differential and integral calculus. It is regarded as a department of applied mathematics rather than of mechanical science. That this should be the case is unfortunate; at the same it is not in the nature of things altogether avoidable. The student cannot afford the time involved in deferring the study of dynamics until he has acquired a working knowledge of the calculus. As a consequence he becomes confused respecting the origin of his difficulties, and possibly attributes to his ignorance of mathematics misconceptions the nature of which may be purely dynamical. It would be of great benefit to him to have the opportunity of attending, before the close of his studies, a short course of lectures on the fundamental principles of the subject, that is to say, the conceptions springing directly from experience, upon which the science is founded. The mind of the individual resembles in its mode of growth the mind of the race. The study of the historical development of mechanical ideas will go a great way in clearing up difficulties which arise from adhering too closely to one line of thought. Many of the greatest advances in science are the result of changes of the point of view. Such changes correspond in some measure with the process known to the mathematician as the transformation of coordinates, a process which often transforms a mass of brain-wearying symbols into ordered groups, instinct with life and

*Address by the Vice-President before Section D. of the Detroit Meeting of the American Association for the Advancement of Science.

meaning. It will be well, therefore, for the student of dynamics occasionally to make the endeavor to transform his coordinates and view the subject from different standpoints. For this purpose it is unnecessary that he should be an expert in refined mathematical analysis. It is requisite, on the other hand, that he should possess, in some degree, what may be called the mechanical instinct. The whole power of modern analysis has not proved sufficient to solve, in its generality, the problem of the three bodies; a problem extremely useful, nevertheless, as an illustration of dynamical principles.

The science of statics, or the laws of composition of forces and couples, was developed from rude experiments made with springs and with strings and weights; the tensions of the strings being measured by the weights. The conditions necessary in these experiments were that the body to which the springs or strings were fastened should be maintained by them at rest, and that all changes of shape and size should have ceased. Statics was thus established without the introduction of the ideas of mass and acceleration. In this stage, however, its laws were supposed to apply only to rigid bodies at rest. The facts to be noted are, that force was recognized as a fundamental conception, and that methods of measuring it and the laws of composition of forces were discovered, without reference to motion except in the respect that rest was supposed to be a necessary condition.

The connections between force and motion, the subject-matter of dynamics, were established by observing the motions of falling bodies, pendulums, bodies rolling and sliding down inclined planes, colliding spheres, bodies connected by strings running over pulleys, etc. In making these experiments it was necessary to know the forces acting. As the only scientific knowledge of force at the time was contained in the laws of statics, the assumption was made that these laws were true, even though the bodies were moving and whether the velocities were increasing, decreasing, or changing in direction. This was a change of the point of view which was fruitful in important results. It was found, however, that while the above assumption was justified in the case of the composition of forces, and in the case of weights when considered as forces acting on the heavy bodies themselves, it was not true to assume that the tension of a string in motion is measured by the attached weight. The true indication of the tension in a string was recognized to be the same as in the case of a spring, viz., the elongation. Again, while in statics, the principal objects were the strings and weights, and the bodies to which they were attached were of little or no account, in the dynamical experiments the bodies assumed importance. The conception of mass was introduced, and was found to correspond with the commercial idea of quantity of material, as determined by the balance and weights. The results of these experiments are contained in the laws of dynamics, or the laws of motion, as they are usually called, which may be summarized as follows:

I. That no change in a body's motion of translation takes place except by the action of external forces.

II. That external forces impress on a body changes of momentum in their own directions at rates proportional to their magnitudes.

III. That action and reaction are equal and opposite, and in the same line.

It seems to be a matter of doubt whether Newton, in his statement of the laws of motion which I have thus paraphrased, intended to affirm that action and reaction are in the same line. Whether there be ground for this doubt or not, the idea is

implied in D'Alembert's principle and is accepted as true.

The third law is a law of force, the value of which is seen when the mutual actions of bodies are to be considered. Without this law the laws of statics and of motion would refer to actions on one body only.

It was evident that the laws of composition of forces could be considered as corollaries of the laws of motion, so that from the latter a more comprehensive view of the measurement of force was gained than from the statical experiments. Thus the statical method of measuring force by balancing the tension of one string or spring against that of another was interpreted dynamically, by assuming that the body upon which the springs acted remained at rest in consequence of receiving from the forces opposite changes of momentum at the same rate. It followed that if the springs were to act singly they would, other things being equal, produce equal rates of change of momentum. Thus dynamics furnished a new method of measuring forces which agreed with that by means of springs.

Further investigation in the light of the new principles showed that the method of measuring forces by weights agreed with the spring measurement and with the dynamical measurement when the condition was observed that the weights were kept in the same locality, but in general not otherwise. Dynamics gave an explanation of this anomaly by showing that the forces of the weights were due to gravity, which evidently might change in intensity from place to place, although the masses of the weights remained unaltered. The measurement of force by weights was thus shown to be a special case of the general dynamical method. Also it resulted that the measurement of force by weights was in principle the same as the measurement by springs, the weight and the earth together constituting a spring whose elastic force is gravity.

It is of little use in the early dynamical training of a student to dwell on the fact that the unit of force in dynamical measure is a force which produces unit acceleration in unit mass. It may even do harm. It may have the effect of leading him to believe that the refined methods of measuring force by means of weights and springs, which are the only methods used in the laboratory, are wrong and that the testing machines and pressure gauges of the engineer are beneath contempt. It ought to be impressed upon him that all the methods of measuring force approved by experience are equally scientific and equally absolute, and will give exactly the same results, aside from unavoidable experimental error, provided that the proper conditions in each case are observed; also that the choice of the method depends, just as in the case of everything else in life, upon the objects in view and the circumstances.

We now come to the period of the development and extension of the laws of motion. While proved in the case of small bodies and motions of limited range, it by no means followed that they applied to the motions of the tides or of the planets. Newton, by the aid of his happy intuition, the law of gravitation, put new meaning into them and extended their jurisdiction over all visible and measurable motions within the solar system.

All motion is, so we are taught, relative; and the motion which is uniform and in a straight line with reference to one set of axes may be varying and in a very crooked line when referred to another set, and perfect rest with regard to a third set. The question then is, for what axes are the laws of motion true? It is very certain that the stresses in the springs by which forces are measured are in no wise affected by the choice of axes of reference.

Imagine a cube of rubber, with several points marked on its faces, and consider the lines joining one of these points with the others. The angles between these lines measure the relative directions of the terminal points from the initial point. Now set the cube in motion; stresses and strains are generated, in consequence of which the relative directions of the lines undergo small alterations. Why do these changes of direction remain within small limits? Evidently on account of the nature of the material connecting the points.

Consider now another system of points whose relative directions as time goes on remain almost unchanged, viz., the fixed stars. Is it possible that they may be moving like the points on the rubber cube? Observational astronomy indicates that they are at immense distances from the earth and from each other. If the law of gravitation holds for them their mutual attractions must be so feeble that they form a practically unconnected system. The constancy of their relative directions cannot therefore be accounted for as in the former case by the action of the matter between them, but must be attributable to some other cause. The distinction between the two cases, which is very real, is recognized by assuming that a line may have absolute direction; and the stars are said to preserve their absolute directions from the earth. Again, the assumption that both the law of gravitation and the laws of motion are true for the solar system leads to the result (in consequence of its vast distance from the stars) that its center of mass has little or no acceleration; in other words, is either at rest or in uniform motion in a straight line.

Now, although the ideas of absolute direction and absolute rest or uniform motion in a straight line may from the kinematical point of view be incomprehensible, yet in dynamics these terms indicate very definite facts. It is only by the choice of the center of mass of the solar system as origin and by using the stars to fix the directions of the axes that it is possible to make the observed motions of the planets fit, at the same time, the law of gravitation and the laws of motion. It is unnecessary to enter into the details of the work; suffice it to say, it is a process of trial and error, of assumption, computation and check by observation.

The following dynamical consideration enables, in certain cases, a more convenient origin to be used than the center of mass of the solar system.

If equal accelerations are impressed on the bodies whose motions and mutual forces are under consideration, by the attraction of the remainder of the solar system, it is evident that their motions referred to an origin at their common center of mass, with axes fixed in direction by the stars, will be affected only by their mutual actions. Also assuming the laws of motion to apply, these motions so measured will show the whole effect of their mutual actions, since the latter have no effect on the motion of their center of mass. It is thus, possible, in discussing the lunar tides, to use as origin the center of mass of the earth and moon, and in the case of terrestrial bodies the center of mass of the earth. It may be noted that whether the primary origin or such subsidiary origins be used, the equations for the mutual forces under consideration are the same; the effect of the change of origin appearing only in the constants of integration. It will be convenient to term all such sets of axes, including the primary set, absolute axes.

It now remains to determine whether the absolute axes will give results agreeing with those already obtained in the small scale experiments, with axes fixed in the earth; and if they do not, whether the discrepancies can be explained.

If no explanation could be given of such discrepancies it is evident that the science of dynamics would be resolved into a bundle of empirical rules, describing the various axes of reference that applied in different cases, and the range of applicability in each case.

In order to make the comparison, it will be necessary to obtain the data required for transformation from the absolute set of axes with origin at the earth's center, to axes fixed in the earth with origin in the locality of the experiments. These data are furnished by astronomical observations. When the transformation is made there appear on the left-hand side, let us say, of the equations the rate of change of momentum of the body relative to the axes fixed in the earth, and on the right-hand side the attractions, tensions and other impressed forces, together with certain terms involving the relative motion of the two sets of axes.

In the equations of the original experiments no terms of the latter kind occurred. There are three ways of accounting for the difference. Either the forces are different in the two sets of equations, or the new terms are so small as to be within the limit of experimental error, or each experiment or class of experiments requires its special set of axes.

Experience shows that the explanation lies in the first or second alternative; the the third is not true.

These terms are generally negligible in laboratory experiments. It is necessary to consider them in the theory of winds and ocean currents. Their presence in the equations has suggested certain experiments with pendulums and gyrostats, which confirm their truth. We are justified by experience, for instance, in believing that in the northern hemisphere moving bodies tend to the right, in the southern hemisphere to the left; bodies moving eastward tend to rise, westward to fall; and that bodies, whether at rest or in motion, tend to move outwards from the polar axis. All such tendencies are represented by the terms under consideration. They may be regarded when written on the force side of the equations as representing relative or fictitious forces; fictitious because they correspond to no actions of matter, but are the consequence simply of the motion of the axes of reference relative to the absolute axes.

Sometimes it happens, as has been indicated, that the discrepancy lies in the fact that the forces in the two sets of equations are different, although referring to the same experiment. Consider the case of a body suspended from a spring. Referred to axes fixed in the earth it is at rest, and the inference is that the attraction of the earth is equal and opposite to the tension of the spring. Referring, however, to the same axes by transformation from the absolute axes, there appears, in addition to the terms representing the tension of the spring and the attraction of the earth, a new term, a relative or fictitious force, known as the centrifugal force. The inference now is that the attraction of the earth is greater than the tension of the spring, instead of being equal to it. If this inference be accepted as the true one the question arises, which of the original forces was wrong, or were both astray? Remembering that the intrinsic indication of the force exerted by the spring is its elongation, and that of attraction the acceleration caused by it, also that acceleration depends on the choice of axes of reference, while the elongation of a spring does not, there can be no hesitation in deciding that the error lay altogether in the estimate of the attraction. The fictitious force, while itself invisible, also rendered invisible a portion of the earth's attraction. By using proper axes of reference its true character is revealed and

its power for evil destroyed. If the mechanism of attraction were not concealed, or if it had some distinguishing mark other than acceleration, and it were possible to experiment with it as with springs, such an error could not be made, even with improper axes of reference.

A convenient way of regarding the laws of motion is to consider, as before, the second law as affirming the relation between force and change of momentum, and the third and first as asserting the principle of conservation of momentum; the third implying that momentum passes from one body to another without change, and the first that the only way by which the momentum of a body can suffer alteration is by part of it passing into another body. Again, if it be assumed that the third law implies that action and reaction are in the same straight line the principle of the conservation of angular momentum will follow.

The statement is sometimes made that the 'bodies' of Newton's laws must be regarded as particles. I cannot take this view; they are real bodies, of all sizes, and with all the qualities known and unknown of such bodies. They are not the imaginary bodies of the mathematician, the dramatis personæ of the algebraic theatre, possessing only the qualities arbitrarily assigned to them for the special purpose of the investigation in hand.

The laws of dynamics thus hold for all bodies within the solar system whose masses, forces and motions have hitherto been observed and measured; but the motions must be measured with essential reference to only one set of axes, namely, a set whose origin is in the sun and whose directions are fixed by the stars.

Kinematics deals with relative motion; Dynamics with the 'Motus Absolutus' of the Principia.

We now pass to the consideration of the laws of energy in their dynamical relations.

In the discussion of statics as the forerunner of dynamics, attention was directed mainly to the springs and strings and weights by which the forces were measured. The original statical experiments may also be regarded as the source of the principles of energy in connection with mechanical science. From this point of view the bodies upon which the forces act come into prominence, not because of their masses as in dynamics, but on account of their shapes, sizes and rigidity. Thus the experiments were made with levers, pulleys, inclined planes, wedges, etc.—in fact, with instruments for doing work, the mechanical powers of the text-books. In the statical principle of virtual velocities we have the origin of the principle of the equivalence of work and energy. To men of all times the most natural way of regarding force has been, as the action by which material is stretched, bent, twisted, broken or displaced, *i. e.*, whereby work is done. Even the word momentum, in the language of ordinary life, implies the power of doing work. It is worth consideration whether it may not be better in the instruction of students to work up to the ideas of dynamics through elementary examples of the equivalence of work and kinetic energy, rather than by taking the ordinary balloon passage to the laws of motion. While less systematic and formal, this procedure would be more natural and probably more useful.

The laws of energy may be summarized as follows. When work is done on a body an equivalent amount of energy is partly transformed and partly transferred without transformation. It is in general partly transmitted to other bodies with which the given body may be in physical connection. Its transformations are into stored energy and dissipated energy. Examples of stored energy are the potential energies due to gravitation, the forces of elasticity, magnetic and electrical attractions and

molecular forces. Such forces are termed conservative. Kinetic energy is another form of stored energy. Energy is dissipated by means of the forces of viscosity and friction, known as dissipative forces. Energy is also stored and dissipated in certain electrical, electro-magnetic, thermal, chemical and other actions which have not been identified with force and which, therefore, are not dynamical.

In order that work may be done there must be a source of energy, or place from which it comes, and a sink, or place to which it goes, together with an energy stream from the source to the sink. When work is done continuously the energy stream is accompanied by a circuit or system of stored energy which acts automatically as a moderator of its fluctuations.

The principle of conservation affirms that energy can neither be created nor destroyed, so that its changes are changes in form but not in amount.

The principle of the equivalence of work and energy is analogous to the second law of motion, considered as expressing the equivalence of impulse and momentum; that of the conservation of energy has its analogue in the third and first laws of motion regarded as affirming the conservation of momentum.

Newton notices this analogy in his scholium to the laws of motion in the words, "just as bodies in cases of collision have the same effect, whose velocities are inversely as their masses, so in putting machines in motion agents have the same effect, whose velocities in the directions of their forces are inversely as these forces." The now well known reference in the same scholium to the action of machines, the importance of which was pointed out in Thomson and Tait's Natural Philosophy, was in continuation of the same line of thought.

The impulse or time integral of a force is fully accounted for by the change of momentum, while the work or displacement integral is only partially accounted for by the change in kinetic energy, in all cases of real bodies. The reason for the difference is that the laws of motion are a complete statement of our experience of force in relation to the motion of a body as a whole, *i. e.*, the motion of its center of mass. On the other hand, the laws of energy require the consideration not only of this motion, but also of all internal motions and forces.

The principle of the equivalence of work and energy is a statement of an effect of force essentially different from its effect in producing change of momentum. It might be supposed, therefore, that this principle would be useful in affording another means of measuring force. The impossibility, in general, of measuring the whole change of energy due to an unknown force acting through an observed distance renders this idea to a great extent fruitless. If the laws of energy are true such a method of measuring force must give the same result as the dynamical method. The measurement of force by springs is based on this principle, and not on the second law of motion. Although no attempt is made to measure the change of energy due to the work of extending a spring, yet experience goes to show that the energy changes due to given extensions made in the same order are constant, and hence the corresponding forces are constant.

The connection between the laws of energy and those of motion may be stated as follows: Energy and work, like force, are fundamental conceptions gained from experience and having various relations with phenomena which can be discovered only as a result of experiment and observation. One of these relations is that work is proportional to the product of force into displacement. This relation is, therefore, a natural law, of the same order of impor-

tance as the second law of motion, and not a mere verbal definition. Experience thus gives a dynamical measure of work as well as of force.

The law of equivalence of work and energy then establishes work as a dynamical measure of energy.

The laws of motion, combined with this law of energy, establish the result that kinetic energy is proportional to the product of momentum and velocity, and thus furnish a dynamical method of measuring energy in its kinetic form. This is the sole contribution of the laws of motion to the science of energy.

It is only in the case of bodies whose internal forces and motions are known, or determinable from assumed data, in other words, imaginary bodies, that the laws of energy, as far as they are considered in dynamics, are included in the laws of motion and therefore become unnecessary, except for the purpose of convenience in mathematical analysis, or economy of thought. Even in such cases the expressions for work and energy retain a flavor of their original meaning and do not altogether degenerate into mere mathematical symbols.

The science of dynamics, as it is understood at the present day, includes among its fundamental principles, in addition to laws of motion, the principle of the equivalence of work and energy, and the principle of the conservation of energy; energy being measured, however, only in terms of force and displacement, or momentum and velocity.

The only actions known in dynamics are force and its integrals, impulse and work. To identify with these all other actions involving the transfer and transformation of energy, such as the conduction of heat, chemical reactions, induction of electric currents, etc., forms to-day the severest task of mathematical physics.

JOHN GALBRAITH.

SCHOOL OF PRACTICAL SCIENCE, TORONTO.

MATHEMATICS AND PHYSICS AT THE BRITISH ASSOCIATION.

MEETING this year at Toronto in the week immediately succeeding the meeting of the American Association at Detroit, the British Association had the advantage of securing the attendance of a number of distinguished American scientists, who added greatly to the strength and interest of the proceedings. Taking Section A alone, it is sufficient to mention the names of Dr. Hill, Professors Michelson and Newcomb, as Vice-Presidents; and of Professors Barker, Carl Barus, Bedell, Carhart, Merritt, Nichols, Rosa, and many others who attended the meetings and assisted at the discussions in the work of the Section.

It is generally conceded, even by the rival sections, that A is not only the first but also the most strongly represented section, if not always in the number of its rank and file, at least in the distinction of its leaders and in the vigor and extent of its work. This year, in spite of the distance from home, formed no exception to the rule. Although some familiar faces were absent, the section formed a very strong and representative gathering of mathematicians and physicists. There were no less than fifty names on the committee, but it would have been easy to add to this number without going beyond the list of those attending the meeting whose work was already known.

In many ways, the extremely varied interests which the Section A represents are doubtless a great element of strength, but there are certain drawbacks in its excessive vitality. It brings together men from a number of different but closely allied departments of knowledge, who, if they did not possess some such common meeting ground, would be less able to keep in touch with each other, and to assist in the general advancement of science. At the same time it cannot be denied that the section is somewhat overburdened with an excess of com-

munications which are too good to refuse, and that in consequence of the press of work and of the extremely mixed character of the audience, the discussions on the various papers, which should be the most valuable and interesting part of the proceedings, are generally of a very perfunctory and almost casual order. Similar considerations lead to the curtailment of the papers as well as of the discussion. Many of the authors are influenced by an undue regard for the feelings of the more popular part of the audience, and are thus impelled to omit technical details of the highest interest and importance for the due appreciation of their work by those competent to judge.

Upwards of 60 communications, out of many more that were sent in, were accepted and read in the course of the five days on which the section met. In order to get through this program, it was necessary to sit till 3 p. m., on many of the days, without any intermission for lunch. On two of the days the section divided into two departments, Mathematics and Meteorology on Monday, Electricity and General Physics on Tuesday. This plan has been found to work well in previous years, but is not without its defects. Professor Rosa, for instance, was engaged in reading a paper in one department at a time when another of his communications was due in the other. He was thus compelled to miss the reading and discussion of a number of papers closely allied to the subject of his second communication, and those present in the electrical department were compelled to miss the description of his most ingenious and complete electrical calorimeter as applied to the verification of the law of conservation of energy in the human body. Under any system of subdivision, it is probable that similar difficulties must occasionally arise, but the question is now under the consideration of a special committee, and it is hoped that some more perfect arrangement may be evolved in time for the next meeting.

An audience of over four hundred assembled in the Chemical Lecture Theatre to hear the address of the President, Professor A. R. Forsyth, who succeeded Cayley in the chair of pure mathematics at Cambridge. His address was an eloquent and convincing vindication of the importance of studying mathematics for its own sake with the single aim of increasing knowledge, and not, as some would have it, from a utilitarian point of view, as an instrument for the use of the engineer, the physicist or the astronomer. The path of practical utility, as he justly remarked, is too narrow and irregular, not often leading far. It is evident from the demeanor of the audience that they were all thoroughly interested and engrossed in the subject of the address, which, it is to be hoped, may do something to moderate the utilitarian and technical spirit, and to check its inroads upon the sanctuaries of university education.

The ventilation of the Chemical Lecture Theatre appears to have been overlooked in its construction; but, in spite of a somewhat asphyxiating atmosphere, the larger, and, we may also say, the wiser part of the audience, remained behind to hear the presidential address of Professor Ramsay to the Chemical Section, on 'An Undiscovered Gas.' Professor Ramsay is a physicist no less than a chemist, and his search for the undiscovered member of the triad of which helium and argon are the extremes, raised many questions of the widest general interest to the physicist as well as to the chemist. The methods which he was compelled to adopt in treating these substances, which have no chemical properties, were also physical rather than chemical, depending on differences of density, refractivity, and rate of diffusion. Helium appears to be unique among elements in possessing an extremely low refractivity in proportion to

its density. The physical methods of diffusion, and of measuring and comparing the refractivities of different gases and mixtures of gases, appear to have been carried to the highest degree of refinement which has yet been obtained, in this nominally chemical research.

After adjourning to the Physical Lecture Theatre, the section took up the ordinary business of the meeting. A paper was read by J. A. Paterson, 'On the Unification of Time,' a question of considerable interest to Canadians. In the discussion, it was pointed out by Professor Rucker that, for the present, international agreement was hopeless. The question had recently been considered by an influential committee of the Royal Society, who had decided that the present was not a suitable time for action. A committee was subsequently appointed by Section A to consider what action could be taken in the matter.

Professor Rucker, assisted by Forsyth and Sowter, showed some photographic records which had been obtained of objective Combination Tones, which were of great interest in connection with certain disputed points in the theory of such tones.

The report of the Committee on Seismological Observations was read by the Secretary, Mr. J. Milne. Among the points specially discussed were the greater frequency of sub-oceanic disturbances as compared with land-quakes, the large number of such movements originating in Tuscarora Deep being taken as a special example. It had also been shown by means of observations of earthquakes taking place in various parts of the earth, and registered by means of one of Milne's horizontal recording pendulums for unfelt earth-movements, that the velocity of propagation of such movements was much higher through the lower strata. The nearer the path to the center of the earth, the higher the velocity. By means of several of these instruments, which are now being set up in different parts of the globe, it is hoped to obtain important information with the regard to the interior constitution of the earth. Such records have also been proved to be of great practical utility in connection with the breaking of submarine cables, and other effects of suboceanic disturbances.

On Friday a paper was read by Dr. N. E. Dorsey, 'On the Determination of Surface Tension by the Method of Ripples.' Dr. Dorsey had applied the method used by Lord Rayleigh with great refinement to the measurement of the surface tension of water and of dilute aqueous solutions. He found that the surface tension was approximately a linear function of the concentration.

Professor H. L. Callendar and H. T. Barnes, of McGill College, Montreal, described their new method of determining the 'Specific Heat of a Liquid in terms of the International Electrical Units.' The practical details of the method have already been completely worked out, and several sets of observations have been taken in the case of water and mercury. The method consists in passing an electric current through a current of liquid flowing in a fine glass tube enclosed in a glass vacuum jacket, which is exhausted as perfectly as possible, and then hermetically sealed. The electric energy is measured by the potentiometer method in terms of the Clark cell and the Standard Ohm. The heat generated is measured by observing the flow of liquid and the steady difference of temperature between the ends of the fine tube. The time of flow is automatically recorded on an electric chronograph on which a standard clock is marking seconds. The difference of temperature is given by a single reading on a pair of differential platinum thermometers.

The method was primarily devised for the purpose of investigating the question of

the rate of variation of specific heat with temperature, which could be determined independently of the absolute value of the Clark cells used in the work. It is also of special interest in connection with the recent proposal of the Electrical Standards Committee of Section A to adopt the Joule or Watt-Second as the absolute unit of heat. According to the most recent reductions, the result of Rowland by the mechanical method, and of Griffiths and Schuster by the electrical method, for the specific heat of water differ by about one part in 400. This discrepancy is possibly due to an error in the value assumed for the Clark cell, but it is interesting to verify the comparison by a totally different method of calorimetry, to avoid any possible errors which may have remained unsuspected in the ordinary method, in which a known mass of water is heated through a certain range of temperature. In the method of Callendar and Barnes the temperature conditions are extremely steady, and observations can be taken under the most favorable conditions. The external loss of heat is reduced to a minimum by means of a vacuum jacket, and can be very accurately measured by varying the electric current and the flow of liquid in a suitable manner. Since there is practically no change of temperature, the correction for thermal capacity of the calorimeter is negligible.

A crowded audience assembled to hear Lord Kelvin on the 'Fuel and Air Supply of the World.' The address, which lasted about half an hour, was very characteristic, especially in the humorous attack on the English system of measures. Assuming that the earth was originally at a high temperature, and that there was at first no free oxygen in the atmosphere, it may be concluded with a high degree of probability that the present store of oxygen has been evolved by the action of sunlight on vegetation. To every three tons of oxygen there corresponds on the average one ton of coal or of fuel derived from vegetation. As there are at present two tons of oxygen to every square meter of the earth's surface, the total oxygen supply may be estimated at about one thousand million million tons, and the total fuel supply at 340 million million tons. According to the estimates of the Coal Supply Commission of 1831, it appears that England, with an area equal to one two-thousandth part of the earth's surface, possesses more than its share of fuel, the greater part of which is available for working. As the coal is used up, if it were not for increasing vegetation, we should be more likely to die from want of air than from want of coal.

Dr. Alexander Johnson, of McGill College, followed with a plea for an Imperial Hydrographic Survey. A committee of the British Association appointed at his suggestion in 1884 had succeeded in inducing the Canadian government to make a grant for the promotion of tidal observations. This grant has recently been reduced, and there was some risk that it might be discontinued altogether at a time when such observations were of special importance. At Professor Johnson's request an influential committee was again appointed to seek the cooperation of the Admiralty in establishing a permanent department.

Professors Ewing and Dunkerley, of Cambridge, England, contributed a paper on the 'Specific Heat of Superheated Steam.' They adopted the method of the throttling calorimeter, which is not so well known in England as in America, but instead of determining the wetness of the steam in terms of the degree of superheating observed they used a separator, and assuming the steam to be dry, deduced the value of the specific heat. A roll of silk was used, following Thomson and Joule, instead of an aperture for throttling the steam.

Professors Runge and Paschen contributed a note in continuation of their well-

known spectroscopic investigations. They find that the spectrum of oxygen consists of six series of lines, two principal groups each with two subordinate groups, having harmonic relations to each other. The spectrum of oxygen is thus analogous to that of helium. At one time it was supposed that this character of the spectrum might indicate that the substance examined was really a mixture of two different elements closely resembling each other in properties. Many elements, such as sodium and lithium, give only one series of lines. This hypothesis has, however, been recently abandoned.

W. J. Humphreys next read a paper on 'Changes in the Wave-Lengths of the Lines of Emission Spectra of Elements.' The changes examined were caused by increasing the pressure of the air surrounding the electric arc up to six or twelve atmospheres, which was found to produce a shift of the line towards the red end of the spectrum, the amount of the shift being nearly in direct proportion to the pressure, and never exceeding a tenth of an Angstrom unit for the pressure employed. The shifts were in general proportional to the wave-length, but different series of lines were differently shifted. Shifts of similar lines of different elements are said to be inversely as the absolute temperatures of the melting points of the substances, proportional approximately to the products of the coefficients of linear expansion of the solid and the cube root of the atomic volume. The effect is, therefore, like the atomic volume, a periodic function of the atomic weight. It is considered that some of these relations may be accidental, as most of the time was spent in measuring the lines and not in hunting after empirical relations.

In making the measurements, the best spectroscopic equipment of the Johns Hopkins laboratory was used. Besides a number of eye observations, several hundred photographs were taken, and almost every known metallic element examined. The shifts due to pressure may be distinguished from those due to the Doppler effect, because different lines of the same element are differently shifted, and the direction of the shift is always to the red. The largest shift observed would correspond to a velocity of recession of some four miles a second.

A communication from Professor Schuster, 'On the Constitution of the Electric Spark,' described measurements of the velocity of translation of metallic particles in the spark. The velocity found was from 400 to 2,000 metres per second.

Professor S. P. Thompson showed some experiments on varieties of cathode rays, which he classified according to their powers of exciting X-rays, of producing fluorescence, and of being deflected or not by a magnet. The ordinary cathode rays after reflection from the anticathode were found to be still fluorescifiant and deflectable, but to have lost their power of exciting X-rays. A third variety was produced by passing the cathode rays through a negatively electrified spiral or sieve, which changed the nature of the fluorescence and rendered them non-deflectable. A fourth variety was found in the funnels of a Holtz tube. Under the hurried conditions of the section meeting, it was not very easy to follow and observe these several effects.

Among the other papers on Friday were two by Professor S. P. Thompson, on a 'Tangent Photometer,' and on an 'Experiment with a Bundle of Glass Plates.' There were also two important contributions from John Hopkins on the comparison of the thermometers used by Rowland in his determination of the mechanical equivalent of heat (1) with the Paris Hydrogen Scale, and (2) with the scale of one of Callendar and Griffiths' platinum thermometers. The results of these experiments were to show that, when reduced to the same thermometric scale, the results of Rowland for the

rate of variation of the specific heat of water were in agreement with those of Griffiths, but there was a difference of about one part in 400 in the absolute value at any point. This point was particularly referred to in the Report of the Electrical Standards Committee, and it was suggested that the discrepancy might be due to an error of 0.1 % in the assumed value of the electrochemical equivalent of silver.

The last paper read was by Professor H. L. Callendar and N. N. Evans, 'On the Behavior of Argon in X-Ray Tubes.' The authors had expected to find that pure argon, in consequence of its inertness and its supposed monatomic character, would give a very constant vacuum in such tubes. They found, however, that if the gas were very carefully dried, the resistance of the tube increased very suddenly, and the electrodes were melted or spattered over the walls as the vacuum approached the X-ray stage. The presence of residual hydrogen appeared to be necessary to enable the discharge to pass from the cathode to the gas. These effects were substantiated by experiments with other gases.

On Saturday the majority of the members dispersed on excursions to Niagara and various other places of interest, and with the exception of the Geological Section there were no meetings.

On Monday the section divided into two departments, Meteorology and Mathematics, and those specially interested in electrical work repaired to Section G, which devoted itself on this day to electrical questions. In the meteorological department papers were read by John Hopkinson 'On Monthly and Annual Rainfalls at Ten Stations in the British Empire, 1877 to 1896.' It appears doubtful, however, whether so listed a series of observations can be taken as representative of the pluviology of the Empire. By Dr. Van Rijckevorsel 'On the Temperature of Europe.' From certain peculiar maxima and minima exhibited by the curves of daily temperature, he considers that the continent may be divided into two regions in which a different type of weather prevails. R. F. Stupart, the Director of the Meteorological Service of Canada, contributed a paper on the 'Climatology of Canada.' F. Napier Denison, from a comparison of simultaneous records of changes of level in the Great Lakes and of smaller undulations in the atmospheric pressure by by means of a sensitive barograph, concludes that the larger differences are due to difference of atmospheric pressure over the extremities of the lake, but may be greatly augmented by the action of the wind on the surface of the water. The smaller undulations appear to be due to atmospheric waves caused by currents in different strata traveling in opposite directions, as shown by Helmholtz. Papers were also contributed by Rotch and Marvin 'On the Exploration of the Air by Kites,' showing how it was possible by means of recording instruments, sent up to great elevations attached to a kite to obtain information with regard to the temperature and hygrometric condition of the air, which would be of use in forecasting. It would appear, however, that there is still much to be done in improving the recording hygrometer.

In the department of mathematics there were several papers of esoteric interest. Alexander Macfarlane made an application of hyperbolic analysis to the solution of the cubic equation. Dr. Harris Hancock discussed the history of the Abelian Functions. Professor O. Henrici proposed a convenient notation in Vector Analysis, upon which it would be difficult to express an opinion without extended use by different workers and authorities in the subject. Professor Michelson and A. W. Stratton described some new Harmonic Analyses, in which they had succeeded in carrying the process as far as 80 terms. Papers were also contributed

by Major MacMahon on 'Partitions of Numbers;' by J. C. Glashan on the 'Quinquisection of the Cyclotomic Equation,' and by Dr. Larmor on 'Jacobi's Last Multiplier.'

On Tuesday the section divided along the lines of Electricity and General Physics, and many members regretted that they were unable to be present in both sections simultaneously. In the electrical department there were a number of papers on electrical waves and oscillations of different forms. Professor Braun showed how, by the action of a magnet on a small pencil of cathode rays directed on to a fluorescent screen, it was possible to demonstrate the form of the wave, either by developing the oscillating line of light into a curve with the aid of a revolving mirror or by using a second magnet to give the corresponding Lissajou figure. The frequency of the coil used was not, however, suitable to show the effects in a sufficiently clear manner to an audience. Professor Rosa exhibited an extremely ingenious mechanism for automatically plotting the form of an alternate current wave by the periodic contact method. At each point of the cycle the instantaneous difference of potential to be measured was found by shifting a contact point on a potentiometer wire till the galvanometer indicated a balance. On depressing a key the point so found was recorded on a cylinder, which was moved forward automatically in step with the periodic contact brush on releasing the key. By this means from twenty to thirty points could be recorded in a minute. The curves exhibited showed in a very remarkable manner small waves due to armature teeth and commutator segments, which could not be obtained with any slower method, owing to the necessarily limited number of points. Taking special precautions to secure very steady running of the machines, he had been able to analyze these curves with great accuracy as far as the fifteenth term of the harmonic series.

W. D. B. Duddell exhibited an instrument of a totally different character which could be applied to secure instantaneous photographs of the forms of these curves even under conditions of rapid change such as occur in studying the alternate current arc. He had succeeded in so reducing the period and adjusting the damping of a galvanometer with a pair of strips stretched between the poles of an electro-magnet and immersed in oil, on the plan suggested by Ayrton and Mather, that he was able to obtain very beautiful records of current and potential simultaneously at the ordinary rates of alteration on a falling plate. So far as could be judged from an inspection of the numerous specimens shown, the effect of inertia was practically eliminated. It would not, of course, be possible to measure the these curves with the same degree of accuracy as those obtained by the point-to-point method, but instantaneous photographs can be secured in cases where the slower method would be totally inapplicable.

After the reading of the Report of the Committee on Electrical Standards, to which reference has already been made, Professor J. V. Jones explained a method of calculating the coefficient of mutual induction of a circle and co-axial helix, by which the labor may be considerably shortened. This calculation is required in the Lorenz method of determining the ohm. Professor Ayrton next gave an account of the experiments in which he had been engaged with Professor Jones in redetermining the ohm by means of the Lorenz apparatus constructed for Professor Callendar, of McGill University. This apparatus has been made by Nalder Brothers, under the personal supervision of Professor Jones, and is considered to be the most perfect apparatus of its kind. The value found for

the ohm was nearly one part in 2,000 smaller than that usually accepted, but the uncertainty of the measurements was due rather to discrepancies in the comparisons of the standard coils than to want of consistency in the readings given by the instrument.

Professor Ayrton also communicated a paper by Mrs. Ayrton on the 'Relations between Arc Curves and Crater Ratios with Cored Positive Carbons,' which is being published elsewhere. Mrs. Ayrton is well-known as an authority on these subjects, but the paper is one which cannot be adequately explained without the curves by which it was illustrated. Papers were also contributed by Cerew and Basquin, 'On the Arc;' by Willard E. Case, on 'Gas Batteries,' and Professor J. C. MacGregor, on the 'State of Ionization of Solutions.'

In the department of general physics, there were a number of interesting papers on acoustics and on astronomical and magnetic observations, but the writer was unable to obtain any adequate abstracts or reports.

On Wednesday, Professor Ramsay read a paper on the refractivity of mixtures of gases. According to his observations, the refractivity of a mixture could not be deduced by the usual mixture formula. The discrepancy between theory and observation in the case of a mixture of hydrogen and helium amounted in some proportions to as much as 3%, with oxygen and nitrogen to 0.35%. These differences were systematic, and appeared to be too large to be due to observational errors. They indicate that the refractivity is not accurately proportional to the partial pressure, but that there is a deviation analogous to the deviations from Boyle's law, and apparently in a similar direction. It must be remembered, however, that the refractivity of helium is so phenomenally low as to make these measurements extremely difficult.

Professor O. Lodge introduced a discussion on 'Zeeman's Discovery of the Effects of Magnetism on Spectral Lines.' These effects have been recently described in a communication by Professor O. Lodge to the Royal Society of London, but it would appear from the discussion which took place in Section A, that the effects are so small even in the strongest fields, and are so difficult of study, that the physical explanation of the effect is still a matter of speculation.

Professor Ayrton communicated three papers by himself and J. Mather, on the use and sensibility of galvanometers, a subject upon which they are universally recognized as leading authorities. He explained the principle of the constant total current shunt, as applied to ballistic galvanometers, proposed a standard method of measuring the sensibility, and discussed the question of short versus long-period galvanometers for very sensitive zero-tests. He also exhibited a very simple and sensitive galvanometer of the D'Arsonval type, with a coil resistance of only 1.9 ohms, time of complete oscillation 7.5 secs., which gave a deflection of 36 millimetres at 2 metres for one microvolt.

A paper on the comparison of certain Thermocouples with the platinum resistance pyrometer was read by Mr. H. M. Tory, of McGill College. He showed that the parabolic formula could be regarded only as a rough approximation to the law of variation of the E.M.F. of a thermocouple. Using a platinum-rhodium couple enclosed in the same tube as the platinum pyrometer, he obtained very consistent results up to 1,000° C., showing deviations from the parabola of the same type as with the copper-iron couple at low temperatures. He showed that the assumption of a straight-line formula for the platinum-rhodium couple, which is often taken as sufficiently correct, may lead to errors of the order of 100° C.

Professor Callendar read a paper by himself and H. T. Barnes, of McGill College, on

'A Simple Modification of the B.O.T. Form of Standard Cell.' In this cell the usual construction is reversed, and the materials are introduced in the inverse order, namely, zinc amalgam, sulphate of zinc crystals, mercurous sulphate paste, platinum wire. The cell is portable and free from diffusion-lag, and is much easier to make and more convenient to use than the H-form. Owing to its shape, which permits of immersion in a water-bath, it is more suitable than the H-form for very accurate work, in which an exact knowledge of the temperature of the cell is required. The same construction is also applied with equal facility to the cadmium cell, but it appears that the latter cells are less consistent than the Clark cells at temperatures between 0° and 10° C.

There was a general consensus of opinion that the meeting had been as well up to the average in the quality and quantity of the work submitted, as it had been thoroughly enjoyable and successful from a social point of view. With so many communications to get through, it is to some extent inevitable that the discussions should be curtailed, but the authors of papers are themselves chiefly to blame in many cases if the discussion appears inadequate. It may be possible in future years to exact more stringently that the author should submit an intelligible abstract in advance, which might be obtainable at an early hour on the day on which the paper is read. In the few cases in which the printed abstracts are available they are frequently allowed to lie on the table, and were of no practical assistance to the discussion, as no one knew of their existence. It is to be hoped that the wide range of the work of Section A will not be allowed to detract from its usefulness, and that the committee appointed to consider the question will succeed in devising some scheme of departmental organization to mitigate the overcrowding of papers in future. HUGH L. CALLENDAR.

THE BOTANY OF THE BRITISH ASSOCIATION.

THERE are few opportunities when it becomes possible for the botanists of America and Europe to exchange views and gain that personal knowledge of co-workers in which lies the real essence of acquaintance among scientific men, beyond those afforded by individual effort. It is true that a large number of American botanists have prosecuted more or less extended studies abroad, both in England and on the continent, and this number appears to be annually increasing. The majority, however, are denied such privileges, and for them it becomes a matter of first importance that occasions should arise when they are able to gain direct acquaintance with those who have been known to them in other ways for years. In 1884 the British Association for the Advancement of Science departed from its time-honored custom and held its first colonial meeting at Montreal. So rare an opportunity was eagerly taken advantage of by a large number of representative botanists from both sides of the Atlantic, and, although it was impossible at that time to fully measure the value of the results to be obtained, it was nevertheless felt that the work accomplished must be productive of great benefit, not only in a general advance of botanical science, but in a far better understanding between the botanists of Europe and America. The lapse of years has fully justified this view, and when it was announced that the British Association intended once more to visit Canada, after a period of thirteen years, the prospect was generally hailed with delight by American botanists, who would gladly see these opportunities for scientific conference become more frequent.

The sixty-seventh annual meeting of the British Association, recently closed at Toronto, will be remembered as a notable one in the history of botanical progress on this side of the Atlantic. The great ac-

tivity and interest which centered in the Botanical Section were largely due to the able and energetic manner in which the President conducted the work in hand. To the botanists of the United States, however, is also due no small credit for their share in this happy result. The determination had evidently been reached on their part to make the botanists of Great Britain feel that, although they were to be within their own domain during the progress of the meeting, there is a brotherhood in science which ignores all geographical and political limitations, and that on these grounds the most cordial sympathy and support should be extended. This was made evident not only in the very fortunate arrangement whereby the Botanical Society of America met at Toronto instead of at Buffalo, and concluded its proceedings as the work of the British Association began, but also in the fact that the majority of the botanists in attendance were Americans, and that a very large proportion—about one-half—of the papers presented were from the same source.

The Section met under the very able presidency of Professor H. Marshall Ward, of Cambridge, England, who was supported by Professor D. P. Penhallow, of McGill University; Dr. W. G. Farlow, of Harvard, and Professor F. O. Bower, of the University of Glasgow, as Vice-Presidents. The attendance was not large, although representative. Of English botanists only eight were present, including, in addition to those already named, Mr. A. C. Seward, of Cambridge; Professor F. Weiss, of Owens College, Manchester; Professor J. B. Farmer, of the Royal College of Science, London; Mr. Harold Wager, of Leeds, and Professor J. R. Green and Miss D. F. M. Berts, of Cambridge.

Among those representing American botany were noted: Dr. W. G. Farlow, Dr. Britton, Dr. Coulter, Professor Barnes, Professor Penhallow, Dr. Galloway, Dr. T. J. W. Burgess, Dr. Bessey, Dr. Arthur, Mr. Webber, Professor Green, Mr. Jeffrey and others. Exceptional interest was added to the proceedings by the presence of Professor P. Magnus, of Berlin, who also contributed a valuable paper 'On the Mycelium of a Witches' Broom Fungus' and otherwise assisted in the work of the Section.

There were twenty-one papers in all presented to the Section, representing original research in nearly all the numerous branches of botanical science. These contributions were, in most cases, of a notable character, and drew forth animated and valuable discussions. The report submitted by Professor Farmer, respecting certain investigations on the 'Fertilization of the Phæophyceæ' conducted under his supervision, already indicates that new and important facts bearing upon the relationships of this group have been obtained. The investigations continue for another year under a renewed grant from the British Association.

Mr. Harold Wager gave an account of some recent studies of the yeast plant and other species of Saccharomyces, with respect to the presence of a nucleus and its constitution in various stages of development. The nucleus in yeast has been a subject of study for the past six or eight years, and its presence, as demonstrated by some seventeen observers, is abundantly confirmed by the results obtained by Mr. Wager. The author has not been able to reach final conclusions respecting the question which has been for some time in controversy as to whether the nucleus possesses a nucleolus or not, but his researches tend to the belief that certain granular bodies in constant association with the nucleus, and which present very different conditions of aggregation at various stages of growth, may represent the nucleolus. It was further shown that, in the process of budding

the nucleus extends into the neck, where it undergoes direct division, one-half remaining in the mother cell, while the other half enters the bud; and that, in the process of spore formation, the nucleus breaks up into two, and then into four, nuclei by a very simple process of karyokinesis. Some of the phenomena observed appeared to be new in the history of nuclear division and require more extended observation, but the paper as a whole offered an important addition to our knowledge of cell life, and proved to be particularly opportune in connection with the joint discussion on the cell held by the botanists and zoologists.

The efforts originally made by Hartig, and later by Brefeld, to study the development and action of wood-destroying fungi as represented by *Stereum hirsutum*, met with failure either through lack of pure cultures or imperfect methods of treatment. Professor Ward presented an account of his own recent studies of this plant, in which he employed blocks of sterilized wood, whereby he succeeded in securing a perfect fructification and observing the plant in all stages of development. The details of the progressive destruction of the woody tissue were also dealt with, and it was shown that the lignified structure gradually yielded to the action of the fungus and passed into the condition of cellulose-like bodies, giving the characteristic iodine reaction, before final consumption. The paper was illustrated by a series of beautifully prepared lantern slides, from photographs and drawings.

Professor Penhallow contributes the results of recent studies of the species of *Picea* occurring in the eastern United States and Canada, in the course of which he showed that the red spruce which had been abandoned as a distinct species since the time of Pursh, and regarded as a form of the black spruce, must once more be restored to the status of a valid species as maintained by Lawson and later by Britton. He also pointed out that there is a well defined variety of the white spruce, hitherto unrecognized, the chief characteristics of which are to be found in the strongly glaucous, rigid, often broad and cuspidate leaves, and distinctly fetid odor which has long led lumbermen and others to designate it by the name of 'Cat' or 'Skunk Spruce.' He proposes to distinguish it by the variety name of *fœtida*.

Mr. Francis Darwin gave a preliminary account of a new method of investigating the behavior of stomata, in which he details the use of a new form of hygroscope made of thin sheets of specially treated horn or 'Chinese sensitive leaf.' One end of a narrow strip is secured to the lower surface of a block of cork, and the angle to which the free end rises becomes the index of transpiration. In application, if the leaf have stomata on the under surface only, the index of the hygroscope applied to the upper side remains at zero, while on the lower side it instantly rises to an angle varying with the condition of the stomata. If these organs are widely open, the angle will be 30°–40° to a horizontal line; if the stomata are closed, the reading will be zero on both surfaces of the leaf. With this instrument a number of well known facts in the physiology of the stomata can be easily demonstrated.

Mr. H. J. Webber, of the U. S. Department of Agriculture, detailed the results of recent studies on the spermatozoids of *Zamia*. By means of a series of beautifully prepared sections he demonstrated the occurrence of unusually large spermatozoids, which, together with their flagellæ, may be seen without difficulty with an ordinary pocket lens. The paper throws new light upon our conception of the sexual elements of the Gymnosperms, and will doubtless serve as a powerful incentive to greater activity in the study of this group of plants.

Among other notable features of the meeting were a joint discussion, together with the zoologists, on the Cell; a public lecture on Fossil Plants by Mr. A. C. Seward, who, since the death of Williamson, has been recognized as the leading paleobotanist in Great Britain; and joint action with the Sections of Zoology and Physiology for the establishment of a biological station in the Gulf of St. Lawrence. While it is intended that such a station shall be primarily designed for economic ends in connection with the fisheries, it is hoped that opportunities may be offered for a limited number of students to pursue special investigations relative to both animal and plant life, and thus to supplement the work of larger stations, such as that at Woods Holl.

The special interest of the Section centered in the presidential address, which dealt in a very masterly manner with the progress of botanical science during the latter half of the Victorian reign. The address was a very noteworthy one from several points of view, though chiefly as an important historical summary. While it would be difficult and altogether unsatisfactory to attempt an abstract of a paper so rich in facts, it may be pointed out that it gave the strongest evidence to show the great dependence of important commercial undertakings and economic processes upon data derived from modern scientific botany, as also the very close relations which exist between chemistry and botany as now known. The address will form a useful key to a much wider literature, and deserves the careful perusal of the specialist as well as the general morphologist.

D. P. P.

MARINE BIOLOGICAL LABORATORY.

A STATEMENT TO THE CORPORATION FROM THE TRUSTEES.

THE annual meetings of the Corporation will hereafter be held at Woods Holl in August instead of at Boston in November, and absent members can now vote by proxy. The Board of Trustees has been enlarged to twenty-seven members, and the new Board, it is believed, fairly represents nearly all sections of this country and Canada. The closer cooperation of all institutions of learning is actively encouraged.

These changes will make possible the attendance of a large number of members, at annual and special meetings, who have been unable to reach Boston during the month of November, and there are already signs of increasing interest in the institution over a much wider area. The members will be glad to learn that, at the recent meeting of the British Association in Toronto, Dr. Dohrn, head of the unrivalled station at Naples, took occasion to speak as from personal knowledge in terms of warm commendation of the work at Woods Holl. The past summer has been highly satisfactory; but the Trustees have been hampered by lack of funds for needed repairs and renewals, and, to some extent, for current expenses. At least $1,000 should be raised before resuming work next summer, and there remains a debt of about $4,700 incurred for the erection of new buildings. This debt should be cancelled in order that a clear balance sheet may be shown before undertaking several most desirable extensions of the plant, some of which are urgently needed. Salaries should be increased, and greater inducements offered to the strong corps of instructors and workers whose collaboration has enabled the institution to attain its present position in the scientific world. Moreover, there is no assurance of permanence in an institution of this nature until it shall have acquired a sufficient endowment or maintenance fund, independent of its land, buildings and equipment (which now represent an investment of over $33,000), to relieve it from danger of extinction by one or more sea-

sons of small attendance. The Endowment Fund now amounts to over $3,500 and has been carefully husbanded, but it should be increased to at least $50,000. And the special funds, the Lucretia Crocker Fund for Scholarships and the Library Fund, may profitably be added to.

One effect of the recent changes in the By-laws will be, or may be, to diminish the special interest in and sense of responsibility for the Laboratory heretofore shown in the city of Boston and its immediate vicinity, to which, as is well known, the institution owes its initial impulse and much continuous and generous support. In appealing, as they do now, to a wider constituency, the Trustees are in no wise unmindful of the debt which the cause of science and of sound learning owes to this intelligent and kindly support in the past, some of which support, as they are assured, will hereafter be extended, with unwearied generosity, from the same locality. The Laboratory now looks to the country at large for its main sources of income and upon all the corporate members, in whose hands the recent changes have placed the entire control, rests the correlative duty of supporting the work. With power comes responsibility.

The Trustees, therefore, have decided to raise the annual dues of members of the Corporation to two dollars ($2.00). The fiscal year now begins on the second Tuesday in August, and this sum is due for the year ending August 9, 1898. Members of the Corporation will kindly forward it, together with all back dues, to the Treasurer, D. Blakeley Hoar, 220 Devonshire St., Boston, Mass.

For the reasons given above, the Trustees also appeal to the members of the Corporation to send with their annual dues such further sums, however small, as the means and interest of each in the work may inspire. All contributions will be duly noted in the annual report which is in course of preparation and will be issued early in the coming year. A contribution of not less than $100 entitles the donor to a life membership, exempt from annual dues, or, at his option, to nominate a person to occupy a private room in the Laboratory, free of charge, during one season. A contribution of $50 entitles the donor to a free scholarship, exempt from tuition fees, during one season. Contributions of smaller amounts will be gratefully received and duly acknowledged.

The forthcoming report will show fully all the recent changes in the organic law of the Association, and will be sent to all members in good standing.

By order of the Trustees,

Henry F. Osborn, *President*,
H. C. Bumpus, *Secretary*,
D. Blakeley Hoar, *Treasurer*,
C. O. Whitman, *Director*.
Edward G. Gardiner, *Chairman of Executive Committee*,
James I. Peck, *Assistant Director, Executive Committee*,
Camillus G. Kidder, *Executive Committee*.

All matters relating to scientific administration should be addressed to Professor C. O. Whitman, University of Chicago, Chicago, Ill. All applications for membership, to the Secretary, Professor H. C. Bumpus, Brown University, Providence, R. I. All dues and subscriptions, to the Treasurer, D. Blakeley Hoar, 220 Devonshire St., Boston, Mass.

A NEW LABORATORY DISH.

In the laboratory of the college we use for routine work the paraffin method almost exclusively. The blocks of tissue are infiltrated in the usual manner, and the sections cut with the Ryder or Minot microtome. The student cuts his sections and fastens them on to the slide by means of Ole-

macher's combined water albumen method, a combination, with certain improvements, of the methods of Gaule and Mayer. These are then placed in the drying oven at a temperature of 37° C. for from 12 to 24 hours, until all the water is evaporated, the paraffin and section having, during the evaporation of the water, straightened out perfectly. The slide is now gently warmed until the paraffin, which has a melting point of 45° C., begins to melt, when it is thrust into kerosene, which in ten minutes completes the removal of the paraffin. The excess of kerosene is wiped off, the slide washed with a few drops of alcohol and then placed in a dish of alcohol; from this dish of alcohol the stain is proceeded with as usual. If the tissue has been hardened in corrosive sublimate it is necessary to carry the cemented section through diluted tincture of iodine to remove the mercurial salt; this is followed by washing in alcohol when the section is ready for staining. The stains are conveniently kept in large salt-mouthed bottles into which the slides are placed for staining, mordanting, dehydrating and clearing. It is usual for the student to take from 5 to 10 slides through the various solutions, at one time, and, in so doing, he not uncommonly scratches the section off of one slide by rubbing it against another. This difficulty arises, no matter whether the method of Gaule, Suchannek's modification of Gaule's method, Gulland's modification of Gaule's method, or, what is better, Heidenhain's water method, be used. Even using any of the collodion methods does not permit us to escape this danger. In order to overcome this, the writer sought very carefully through the dishes which have been designed by various workers, but failed to find anything which was ideally available. True, Ranvier has designed a rack upon which a number of slides may be supported, but this is entirely too cumbersome for general laboratory use, and besides involves a large amount of fluid, which makes it an expensive luxury. With these points in view, I have devised a dish which is expected to overcome some of the above difficulties.

The inside measurements of the dish are $3\frac{1}{2}$ inches in height, 1 inch square at the bottom, $1\frac{3}{8}$ inches square—three inches from the bottom, and $1\frac{3}{4}$ inches in diameter at the top, which is round and closed by means of a ground, grooved, Stender cover, which, of course, fits air-tight. In order to render the dish stable, the base is the broadest and heaviest part, measuring nearly $2\frac{1}{2}$ inches in diameter. Extending upward from the bottom of the inside of the dish, on two opposite sides, are eight ribs, four on each side, forming between them three grooves sufficiently wide to admit, in each groove, two slides of ordinary thickness. There can, also, be placed in the outside groove, between the outside ribs on each side and the inside of the dish two slides. This gives the dish, for ordinary purposes, convenient and not crowded, accommodation for eight slides standing on end; or, if the sections be not large and the slides not thick, four slides may be placed outside of the ribs, two on each side back to back.

An ordinary Stender dish requires about 120 cc. of fluid to immerse a slide sufficiently to cover a section cemented to its center. The above dish requires less than $\frac{1}{3}$ of that amount to secure an equivalent degree of immersion. Of course, these dishes vary slightly in their capacity, as all pressed glassware does; such a variation, however, does not amount to more than from 10 to 15 cc.

Where, for reasons of economy, or otherwise, it may be desirable to close the top of the dish by means of a cork or rubber stopper, the expense may be materially reduced. When closed by means of a glass cover, as described above, and shown in the

illustration, the cover and the dish will each bear the same number cut in glass, so that the student, working at his desk, may easily avoid mixing the covers which would not only be detrimental by mixing incompatible fluids; but, as each lid can be ground only to fit the dish which accompanies it, exchanged lids will not fit tightly.

In order to facilitate cleaning and to avoid inaccessible corners, all the corners are rounded.

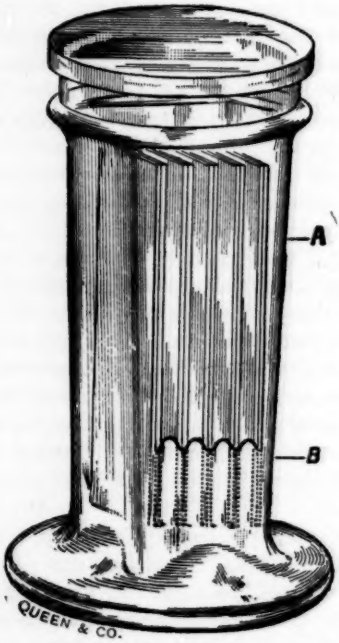

Fig. 1.—This cut is about $\frac{3}{4}$ of the exact size of the dish. At A can be seen ten (10) slides, placed back to back and passing down between the ribs at B. Since this figure was drawn the width of the base has been increased, so that the base is now the width as shown in Fig. 2.

The advantages claimed for the dish are: (1) Convenience, in that a number of slides can be safely handled at one time. (2) Great economy in the reagents; not only is the amount used less than is required by the use of Stender dishes, but in case, as will not uncommonly happen with students, anything occurs which ruins the contained fluid the loss may be materially less. (3) Solidity: no other dish of the same height and the same capacity possess the same solidity. (4) Contained fluids are prevented from evaporating by the tight-fitting top. This is not secured in the Naples dish.

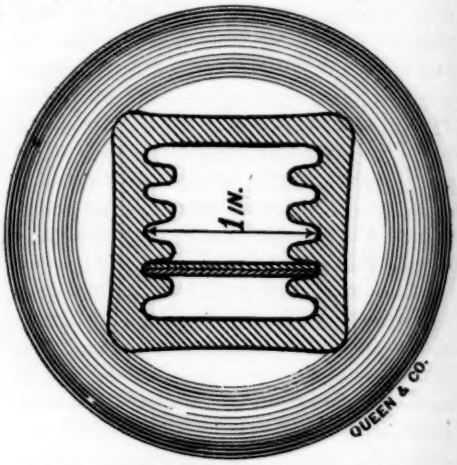

Fig. 2.—This represents a transverse section of the dish at the point marked B in Fig. 1. In this view we are looking down into the dish from above; the ribs and the intervening grooves are shown. The two arrows mark the position in which the ribs are lying and the two points, between which it is exactly 1 inch. Just to the left of the arrow is shown a transverse section of two slides placed back to back, as is usually done for staining.

I desire to express my appreciation of the help given me by Messrs. Queen & Co. in securing working drawings from which the above cuts have been made.

W. M. L. Coplin.
Jefferson Medical College.

NOTES ON INORGANIC CHEMISTRY.

The address of Professor William Ramsay, President of the Chemical Section of the British Association at Toronto, was out of the usual order. It was entitled 'An

undiscovered gas,' and narrated a search for an element with the atomic weight of 20, lying in the periodic system between helium and argon. Many 'triads' are found in the periodic system, with a difference in atomic weight of about 36 between the extremes, viz.: fluorin, chlorin, manganese, 19–55; oxygen, sulfur, chromium, 16–52; nitrogen, phosphorus, vanadium, 14–51.4, etc. If argon has an atomic weight of 40 and helium of 4 there might be expected a triad here, with a middle element of atomic weight about 20. Professor Ramsay and his assistant, Mr. Travers, made a diligent search for this element, which would, like argon and helium, probably be an indifferent gas. The gases from various minerals and mineral springs were carefully examined in vain. Helium was then fractioned by diffusion through porous plates. After 180 diffusions two fractions were obtained, the larger portion having a constant density of 1.98, that is pure helium, while the smaller portion had a variable density, and was finally proved to be helium with a small portion of argon. This search also proved fruitless. The non-existence of the gas is, however, not proven; helium itself in fergusonite, one of the minerals which yields it in reasonable quantity, is present only to the extent of 33 parts in 100,000, and if the new gas, as is by no means improbable, occurs far less abundantly than helium it will be a work of extreme difficulty to separate it from helium or argon.

IN the last *Chemical News*, G. G. Boucher describes a possible new element in cast-iron. He has found it to the extent of a few thousandths per cent. in the residues left after dissolving iron in sulfuric acid. The metal seems to possess some of the reactions of tungsten and of antimony, but has not yet been identified with any known element.

J. L. H.

SCIENTIFIC NOTES AND NEWS.

MEETING OF THE TRUSTEES OF THE MARINE BIOLOGICAL LABORATORY.

A MEETING of the Trustees was held at Woods Holl, Mass., upon Friday, September 10th. Thirteen members of the Board were present, including the Director, Professor Whitman; Professor Clarke, of Williams; Professor Macfarlane, of Pennsylvania; Professor Osborn, of Columbia; Mr. E. G. Gardiner, of Boston; Professor Bumpus, of Brown; Professor Penhallow, of McGill; Professor Metcalf, of Baltimore; Professor Patten, of Dartmouth; Professor Conklin, of Pennsylvania; Professor Morgan, of Bryn Mawr; Professor Peck, of Williams; and Mr. C. G. Kidder, of New York. The first business was the election of a President in place of Professor Farlow, of Harvard, resigned, and Professor Osborn, of Columbia, was chosen by ballot. Mr. D. Blakeley Hoar, of Boston, was elected Treasurer in place of Mr. Laurence Minot, resigned, and a resolution was passed gratefully acknowledging Mr. Minot's long and generous services to the Laboratory during the past four years. Professor Bumpus, clerk of the corporation, was elected Secretary. According to the new By-Laws, the business of the Trustees will be largely transacted by an Executive Committee, which consists of the principal officers of the Association and three members at large. This Committee was constituted for the coming year as follows: at large, Messrs. Gardiner, Peck and Kidder; and *ex officio*, Messrs. Osborn, Whitman, Bumpus and Hoar. The powers of the Executive Committee were carefully defined and limited, and this Committee was instructed to keep formal record of all its business and report to the Trustees at each meeting. A very full report of the financial condition of the Laboratory was received from the retiring Treasurer, Mr. Laurence Minot, and presented, with an analysis of the receipts and expenditures of the last season, by Mr. Kidder. It was shown that the Laboratory is practically self-supporting, but that the interest and other general charges cause an annual deficiency, which must be met by special subscription. The report of the Director was deferred until the next meeting of the Board. Two important Committees were chosen,

namely, upon Collegiate Cooperation as follows: Professor Libbey, of Princeton, Chairman; Professors Whitman, Macfarlane, Penhallow, Gardiner, Mall and Osborn; also a Committee upon Admission to Membership in the corporation, Professor T. H. Morgan, of Bryn Mawr, Chairman; Dr. E. G. Conklin, Dr. J. P. McMurrich, Dr. W. F. Ganong, Dr. E. G. Gardiner and Miss Katharine Foot. It was decided to hold the next full meeting of the Board at Ithaca, during the meeting of the American Society of Naturalists in December, and to issue the annual report immediately thereafter.

THE JOHNS HOPKINS BIOLOGICAL STATION IN JAMAICA.

We have received from Mr. J. E. Duerdon, curator of the Jamaica Institute at Kingston, some notes regarding the researches undertaken this summer at the Marine Laboratory at Port Antonio under the charge of Professor J. E. Humphrey, whose sad death we were recently compelled to record. The party, twelve in number, secured two well-lighted rooms in the Titchfield Hotel of the Boston fruit company for a laboratory which afforded accommodation for eight tables, the necessary apparatus and reagents being brought from the University Laboratory. From the shallow waters around the harbor collections have been made in most of the various groups of animals, while the land has also been scoured for representatives of the fauna and flora. It was not found possible to carry on much dredging. In the facilities for collecting and in the richness of forms met with, the locality has been shown to surpass Port Henderson in many ways; though, owing to the continuous absence of a smooth sea about the margin of the coral reefs, Port Antonio compares unfavorably for reef work with the conditions to be met with, for some hours each morning, at the Port Royal Cays near Port Henderson.

Professor Humphrey was giving special attention to the shell-perforating algæ or sea-weeds and to the embryology of certain groups of the flowering plants, particularly among the latter to those of the pepper and ginger families. Dr. F. S. Conant continued investigations begun by him last summer upon the *Cubo-medusæ*, a rare group of jelly-fish of which two species have been found in extraordinary abundance in Jamaican waters. The chief object of investigation this season has been the function of the sensory organs of the jelly-fish, and material has been prepared with especial reference to a study of the changes, under the influence of light and darkness, in the pigment or coloring matter of the retina of the eyes. Dr. H. L. Clark has been engaged in a continuation of the work which he also began last summer on the Echinoderms (star-fish, sea-eggs, sand-dollars, sea-cucumbers, etc.), of the island, giving especial attention to the Holothurians or 'sea-cucumbers,' forms of life which are very abundant around Jamaica. Over fifty species of the group of the Echinoderms have now been collected by him and other workers, some of which are possibly new to science. Mr. Sudler has been studying the life history of *Lucifer*, one of the small crustaceæ; Mr. Greve, Ophiurius, or sea stars, and Mr. Berger, especially pseudo-scorpions. Collections have been made by Mr. A. Fredholm, of the Smithsonian Institution, Mr. Wilson and others. Mr. Duerdon was allowed the facilities of the laboratory and made a study of the Actiniaria.

THE CONFERENCE ON THE SEAL FISHERIES.

The British Foreign Office has issued a blue book of 130 pages containing the correspondence with the United States government respecting the seal fisheries in Behring Sea. Lord Salisbury, replying to Secretary Sherman's despatch of May 10th, sent a short note to Ambassador Hay on July 28th. We reproduce this note, as it shows that the conference in Washington is intended to be strictly scientific in character.

"I have to state that her Majesty's Government are willing to agree to a meeting of experts, nominated by Great Britain, Canada and the United States, in October next, when further investigations to be made on the islands during the present season will have been completed.

"The object of the meeting would be to arrive at correct conclusions respecting the numbers, condition and habits of the seals frequenting the Pribylov Islands at the present time, as compared with several seasons previous and subsequent to the Paris award.

"It seems to her Majesty's Government that Washington would be the most suitable place for such meeting.

"The other portions of Mr. Sherman's despatch, in so far as they require any reply from her Majesty's Government, have been answered by anticipation in despatches which I addressed to her Majesty's Ambassador at Washington on April 2 and May 7 last, and which have been communicated to the Government of the United States."

Russia and Japan have signified their intention of being represented at the conference on the invitation of the United States. The United States will be represented by ex-Secretary John W. Foster and ex-Assistant Secretary Charles S. Hamlin. It has been arranged that President Jordan, of Stanford University, and his assistants, as well as the British scientific experts, shall appear personally before the conference to give the results of their investigations.

GENERAL.

THE Tenth Annual Winter Meeting of the Geological Society of America will be held at McGill University, in the city of Montreal, on December, 29, 30, 31, 1897. Details of the meeting will be announced in a circular to be issued by the Secretary, Professor Herman LeRoy Fairchild, about November 1st.

THE Berlin Academy of Sciences has made an appropriation of 3,000 Marks to Professor B. Hagen, Frankfurt, for the publication of an anthropological atlas; one of 1,500 Marks to Professor Kohen, Greifswald, for mineralogical researches, and one of 800 Marks to Professor R. Bonnet, Greifswald, for anatomical researches.

THE Dutch Academy of Sciences at Harlem has proposed seventeen subjects for papers to be presented before the beginning of next year. A gold medal is offered in each subject, or, in its place, 500 florins, with an addition of a further 500 florins in special cases. The essays may be in English. The details may be secured from the Secretary of the Academy, Professor Bosscha, Harlem.

LORD KELVIN has returned to New York from the Pacific coast and is at present the guest of Mr. John Bottomley, at Southampton, L. I. He proposes to make another short visit to Canada, and after visiting Mr. Westinghouse at Lennox will return to Great Britain.

WE learn from *Natural Science* that Dr. Henry Woodward, keeper of the department of geology in the British Museum (Natural History), has been permitted by the Treasury to retain his office for another two years. According to the rules of retirement in the civil service, his term of service would have expired next November.

MR. PERCY EMARY has been elected Secretary of the Geologists' Association, of London.

MR. HENRY W. SAGE, President of the Board of Trustees, of Cornell University, died at Ithaca, on the night of September 17th, at the age of eight-three years. Mr. Sage had given more than one million dollars to Cornell University and had been a generous donor to other educational and public institutions.

WE regret to record the death, in Assam, on July 29th, of Samuel Edward Beal, at the age of sixty-two years. He had made contributions to a wide range of sciences, including geography, astronomy, philology and agriculture.

SIR EVERETT MILLAIS, the author of numerous publications on scientific dog-breeding, and at one time editor of the *Stockkeeper*, died at Shepperton, on Tuesday, 7th. Sir Everett introduced into England the Basset hounds whose pedigrees Dr. Galton recently used for his important study on heredity.

MR. R. T. GUNTHER has gone to Lake Urumiya, on the Persian frontier, with a view to studying the fauna of the lake.

THE extensive collections of fossils made by Mr. F. E. Gurley, Danville, Ill., formerly State Geologist, is offered for sale.

THERE has just been added to the Philadelphia Museums a laboratory of tests and technology for the examination and analysis of raw and manufactured products.

COL. YOUNG, United States Army, acting Superintendent of the Yellowstone Park, has made a report to the Secretary of the Interior, stating that black bears and coyotes have multiplied so rapidly in the Park as to become annoying, and recommends capturing some of the bears for zoological gardens and killing some of the coyotes. He states that some of the people

living near the Park object to the protection of wild animals in their vicinity.

Mr. J. G. Jack opened, on September 18th, a course of lectures at the Bussey Institution, Arnold Aboretum. The lectures are popular in character and are followed by field meetings in the Aboretum. Subsequent lectures will be given on the following subjects: September 22d, maples and cherries; September 29th, thorns, locusts and hollies; October 2d, ashes and sumachs; October 6th, walnuts and hickories; October 9th, cornels and viburnums; October 13th, elms; October 16th, oaks.

The September number of the *American Naturalist* is the first to be edited by Dr. Robert P. Bigelow, of Boston, assisted by an Editorial Board, the names of whose members are not given, and a number of associate editors. To these have been added since the last issue of the journal, Messrs. G. Baur, C. E. Beecher, D. H. Campbell, J. H. Comstock, W. M. Davis, D. S. Jordan, C. Palache, H. M. Richards, W. E. Ritter, F. Russell, W. Trelease, S. Watasé. The strong hand of Professor Cope will be greatly missed in the *Naturalist* as elsewhere, but the continued usefulness of the journal appears to be assured under its new management. There is undoubtedly room in America for a monthly journal devoted to the natural sciences, in addition to the special journals devoted to a single science. With the *American Journal of Science* occupied more especially with the physical and geological sciences, the *American Naturalist* for the natural sciences and special journals for each of the sciences, America is admirably provided with the means of publication so essential for the advancement of science.

We quoted recently an editorial article from the *Journal of Geology*, on the debasement of the Missouri Geological Survey. The current number of the *American Geologist* also contains an editorial on the subject, from which it appears that Governor Stevens appointed a board consisting of political workers of the lowest type, Professor E. M. Shepard, of Drury College, Springfield, the only scientific member of the board, having resigned, and that the State Geologist appointed by them has no scientific qualifications of any sort. The records and cabinets of the Survey, which have been accumulating for the past eight years, under the present law have been consigned to the attic of an old building; all field work has been abandoned and several pieces of work, almost ready for publication, have been thrown aside. The work of the Survey at present appears to consist of drawing the usual salaries from the State Treasury. We believe that public sentiment, when expressed, is sufficient to prevent the subversion of science and education to politics, but it is often difficult to secure the expression of this sentiment, especially in cases which appear to be local in character.

From the *Sydney Morning Herald*, *Natural Science* condenses the following information regarding the second expedition to make deep borings into the coral atoll of Funafuti, which set sail from Sydney on June 3rd: Toward the expense of the expedition, Miss Eadith Walker, of Yaralla, has contributed £500; the government of New South Wales has lent a diamond drill; the Hon. Ralph Abercromby has furnished an oil-engine at a cost of £100; the Hon. H. C. Dangar and Professor T. P. Anderson Stuart have provided a fine boat; the Royal Society, London, contributes £100 directly, and probably another £100 through its coral-boring committee; finally, the London Missionary Society has offered to bring the party back to Sydney in September. The expedition is under the auspices of the Royal Geographical Society of Australasia, and its leader is Professor T. W. E. David, of Sydney. He and Mr. G. Sweet, of Melbourne, are going at their own expense, and will take charge of the borings. Mrs. David accompanies them as store-keeper and botanical collector. Mr. W. Poole, an engineer of Sydney University, will manage the light boring apparatus, and will be aided by Mr. Woolnough, who also takes charge of the zoological collecting. These gentlemen give their services free. The large diamond drill is in charge of Mr. Hall, a foreman of considerable experience, who has under him two sub-foremen and three drill-workmen. In view of the difficulties already met with at Funafuti, a special boring plant has been provided under the direction of Chief-Inspector W. H. J. Slee, and weighs over 25 tons. The main bore, on the

central island of Funafuti, will be begun with a standpipe having an inside diameter of 6 inches, and the lining pipe at first is to be 5 inches inside diameter. If, at two or three hundred feet, the friction should become too great, 4-inch pipes will be lowered inside these. It is thought that the foundations of the atoll will be reached between 200 and 500 feet, but the apparatus taken permits of a depth of 1,000 feet being reached. The core obtained will be forwarded first to the Royal Society of London, which will return one-half to the Royal Geographical Society of Australasia. The expedition will also make smaller borings on the sand cay in the middle of the lagoon, will conduct dredging operations for Sydney University and the Australian Museum, and will collect samples of sea-water for Professor Liversidge to examine for gold.

THE Philadelphia Normal School has this year established a psychological laboratory equipped for studying the senses and mental processes. Ten years ago there were only two psychological laboratories in America; at present they form an integral part of nearly all our universities and larger colleges. Their extension to normal schools is a forward step of importance in educational methods.

PSYCHOLOGICAL laboratories will probably also be established soon in hospitals for the insane, in asylums for the defective classes and in prisons. A beginning has been made in several places, but the first well equipped laboratory is now being established in the Illinois Eastern Hospital, under the direction of Dr. William O. Krohn, lately professor of psychology in the University of Illinois. A laboratory of this character will be of great practical value to the patients in the asylum, and may also be expected to make valuable contributions to psychology. As an organ for the publication of its scientific work, the Illinois hospital is about to establish a laboratory bulletin, which will appear at least four times a year. Subscriptions, $2.00, may be sent to the Hospital at Hospital, Ill.

AMONG papers announced to be read at the next meeting of the Australasian Association for the Advancement of Science at Sydney next Christmas are the following: 'The Classification of Eucalypts,' by J. G. Luckman; 'A Statistical Account of Australian Fungi,' by D. M'Alpine; 'The Algæ of Victoria,' by H. T. Tisdell; 'Flowers of the Order Proteaceæ,' by J. Shirley; 'Underground Fungi of Tasmania,' by L. Rodway; 'Australian Oceanography,' by T. W. Fowler; 'On the Formation and Structure of Coral Reefs,' by J. J. Wild; 'The Dialectic Changes of the Indo-Polynesians,' by the Rev. S. Ella; 'The Oceanic Peoples,' by E. Tregair; 'The Ancient Geography of the Maoris' and the 'Geographical Knowledge of the Polynesians,' by S. Percy Smith; 'The Mythology of the Efotese,' by the Rev. Dr. Macdonald; 'Old Samoa' and 'Australian Cave Paintings,' by the Rev. J. B. Stair; 'The Pankuma Natives,' by the Rev. F. J. Paton; 'Notes from Ambrom,' by the Rev. Dr. Lamb; 'The Tongans' and 'The Tongan Language,' by the Rev. J. E. Moulton; 'Ancient Maori Rites and Customs,' by Mr. Elsdon Best; 'The Food of the Ancient Maoris,' by the Rev. J. G. Hammond; 'Anthropometric Data, taken from School Children at Randwick,' by Jas. A. Dick; 'The Characteristics of Australian and other Diamonds,' by E. W. Streeter. The sub-committee of the council appointed to consider the matter of excursions, entertainments, visits to works, etc., has not yet completed its arrangements, but a harbor excursion had been decided upon, and two popular lectures, with possibly a third one, for workingmen, also a concert, at the University, and a conversazione by the Royal Society.

AN International Congress against alcoholism met at Brussels from August 30th to September 3d. It was under the patronage of King Leopold, and was presided over by the Minister of Agriculture.

THE sixth session of the International Institute of Statistics was opened at St. Petersburg by the Grand Duke on August 30th, holding its sessions simultaneously with those of the International Geological Congress. Numerous papers were presented dealing with military anthropometry, criminal statistics, the production of the precious metals, agricultural products, etc. Dr. Körösey, director of the statis-

tical bureau at Buda-Pesth, presented a plan for a simultaneous census of the population of the world in 1900.

The steamship *Hope*, with Lieutenant Peary and the several scientific parties who accompanied him, arrived at Sydney, C. B., on September 20th. Lieutenant Peary has secured the large Cape York Meteorite destined for the American Museum of Natural History.

A proposition has been made for the establishment of an agricultural experiment station in Madagascar for the introduction of foreign plans of economic value and the study of those native to the island.

It is stated in *Nature* that Mr. C. Michie-Smith, the Government Astronomer at Madras, in his reports for the year ending March 31st, says that, as regards the staff, the government has sanctioned the revival of the appointment of a chief assistant. The past year has been conspicuous by the great amount of heavy rain, and both the director's and assistants' houses have suffered considerably. Observations for time have, as usual, been carried on, and the investigation for the determination of the divisions error of the Meridian Circle has been completed, no less than 72,192 micrometer readings being employed. The Madras Catalogue has further advanced, and the mean places for the first sixteen hours have been deduced. Proposals have been sanctioned for observing the total eclipse of the sun next January, and Karad has been fixed upon as the most suitable station.

In an address on 'Medical Botany,' presented before the Section of Materia Medica, at the recent meeting of the American Medical Association, and printed in the Journal of the Association, Professor Trelease states that while botany is still taught, to a certain extent, in medical colleges and schools of pharmacy, an analysis of the appropriateness of this study in the curriculum of either school has led him to the conclusion that for the physician it is to be regarded as an accomplishment rather than a necessity, inasmuch as in the medical practice of to-day prepared drugs and fluid extracts are prescribed, rather than the crude material, which in any event rarely comes under the physician's own observation, his knowledge dealing with the physiological rather than the physical properties of the remedial agents employed by him. While the pharmacist still has some occasion for discriminating between crude drugs, Professor Trelease concludes that even for him the botanical knowledge required is rather that of pharmacognosy than of botany in the ordinary sense; and the opinion is expressed that a knowledge of medical botany, in the old sense, is to-day essential rather to the expert of the manufacturing house than to either the physician or the pharmacist. Attention, however, is called to that branch of medical botany which has recently come into nearly all of the better equipped medical schools, dealing with the bacteria of disease, although even here it is argued that the study is rather for the expert than for the everyday practicing physician.

The committee of the British Association appointed to report on the elucidation of the life conditions of the oyster under normal and abnormal environment, including the effect of sewage matters and pathogenic organisms, presented at Toronto a report on the green disease, drawn up by Professor Herdman and Professor Boyce. They conclude by stating that there can by no doubt that Ryder, in America, about 1880, investigated the same kind of green oyster with which they are dealing. He showed that the green coloring matter was taken up by the amœboid blood-cells, and that these wandering cells containing the pigment were to be found in the heart, in some of the blood-vessels and in aggregations in 'cysts' under the surface epithelium of the body. He describes the color (in the ventricle) as a 'delicate pea-green,' and states that it is not chlorophyll nor diatomine; he suggests that it may be phycocyanin or some allied substance. The committee have now shown that it is due to a copper compound, and consider that Ryder came nearer to what they now consider to be the truth than any previous investigator has done. He was trying to show that the color was derived from the food. Carazzi has recently suggested that the color (this, it must be remembered, is in the Marennes oyster), due to iron, is derived from the bottom on which the oyster is lying. The committee have tried numerous experiments in feeding oysters on iron and

copper salts, both soluble and insoluble, of various strengths, and also in keeping oysters on a bottom of iron or copper salts —including rusty iron, old copper and copper fillings—but in none of these experiments (the full details of which will be published later) have they got sufficiently consistent and continuous results to enable them to determine whether or not the animal obtains its copper from the contents of the alimentary canal or from the water through the surface of the body. These experiments and observations are still being carried on. They add that the green oysters containing copper are found in some localities where there can be no question of copper mines or old copper from ships' bottoms, and suggest that the pigmentation may be due to a disturbed metabolism whereby the normal copper of the body becomes stored up in certain cells.

UNIVERSITY AND EDUCATIONAL NEWS.

IT will be possible for Columbia University to open its academic year at its new site on November 4th, though there may be some delay in certain of the laboratory courses. It is noteworthy that of the six buildings now erected, two are for general university purposes, a library and university hall (which at present contains only the powerhouse and gymnasium), while the four other buildings are for the sciences, Schermerhorn Hall for the natural sciences, Havermeyer Hall for chemistry, and halls for physics and engineering. These buildings for the sciences have been erected at a cost of over $1,200,000, and demonstrate the importance of the place now occupied by science in a modern university.

AT the opening exercises of Dartmouth College, President Tucker stated that the plans are well formulated for the proposed new physical laboratory, the result of the $75,000 bequest of the late Charles T. Wilder, of Lebanon, N. H. The committee has set apart $50,000 for its erection and $20,000 for maintenance. Additional appropriations have been made for an observatory, foundations for which will be laid at once.

OF the colleges that opened last week, Dartmouth, Lafayette and Dickinson report increases in the entering classes, which are 185, 106 and 60 respectively. The classes at Union and Beloit are smaller than usual.

THE Hon. William L. Wilson, formerly member of Congress and Postmaster-General, was inaugurated as President of Washington and Lee University, Lexington, Va., on September 15th. Addresses were made by President Gilman, Johns Hopkins University; Chancellor Kirkland, Vanderbilt University, and Professor Cameron, in the place of President Patton, Princeton University. President Wilson made an inaugural address.

THE Rev. James G. K. McClure, a Presbyterian clergyman, has been elected President of Lake Forest University.

AT Union College Mr. Frank S. Thompson, A.B. (Princeton), has been appointed assistant in physics, and Dr. A. A. Tylor, A.B. (Lafayette) and Ph.D. (Columbia), instructor in biology.

DR. W. E. THOMSON has been appointed professor of physiology at Anderson's College, Glasgow.

PROFESSOR CARL FRIEDHEIM, of Berlin, has been appointed professor of inorganic chemistry in the University at Bern, and Dr. Rodet professor of bacteriology at the University at Lyons.

DISCUSSION AND CORRESPONDENCE.

TYPES IN NATURAL HISTORY AND NOMENCLATURE OF RODENTS.

TO THE EDITOR OF SCIENCE: Three communications have recently appeared in SCIENCE, directly or indirectly relating to work of my own, and I would ask your permission to say a few words concerning them.

The first two are Mr. Charles Schuchert's paper on 'Types in Natural History*, and Dr. Merriam's† critique on it, and it is to the latter I would first refer.

With characteristic emphasis Dr. Merriam scorns Mr. Schuchert's suggestions for further names to represent different classes of types, and incidentally speaks of 'several obsolete

*SCIENCE, V., p. 636, April 23, 1897.

†SCIENCE, V., p. 731, May 7, 1897.

terms which have never been used, as far as I am aware, even by the man who proposed them.' This statement is not quite correct. 'The man who proposed them,' myself, has already used them several times in print, oftener still in labeling and registering specimens, and has every intention of continuing the practice. Nor is he the only one who has done so. Moreover, had none used them as yet, in print, four years is rather a short time in which to consider obsolete terms admittedly proposed only for occasional use. The clear expression by such words of the exact relations of the specimens under discussion to the original description has been found of so much value by those who have used them that it is easy to sympathize with any one dealing with the classes of types that Mr. Schuchert refers to, wishing to have equally handy names by which to speak of them.

Mr. Schuchert has proposed to alter the definition of a *paratype* so that it should only apply to such specimens as are described or measured in the original description. This seems by no means an improvement, as the idea of a paratype is that it is one of the specimens whose examination induced the author to found a new species. In what way he worded his description, which specimens he mentioned and which he did not, in no way affect this central idea. Moreover, it is just the more aberrant individuals, and the extremes in measurement, that would be likely to be mentioned, while those that are best and most representative as paratypes would tend to be passed over in silence.

Probably Mr. Schuchert's '*plastotype*' will be of use to paleontologists and others having occasion to deal with casts, but I fail to see the benefit of his terms *hypotype* and *genotype*, of which the former is too general to be of much definite use, while the latter is based on a confusion of ideas, as while the type of a species is a *specimen*, that of a genus is a *species*, so that no *specimen* can be typical of a *genus*.

The objection to 'hypotype' as being too general and covering too many specimens of different origins applies even more strongly to Lord Walsingham and Mr. Durrant's proposed extension* of *metatype* to cover *any* specimen named by the original author, whether topotype or not. Many a museum worker, who has to name large series of specimens from all sorts of localities, must constantly put under one of his own names specimens which may be anything but typical, and it would be absurd to call the whole of a museum series of a common animal 'metatypes' merely because the name of the species happened to have been proposed by the person who determined the specimens. Probably this result of their proposal had not presented itself to the authors referred to. But after reducing 'metatype' to its original sense, Walsingham and Durrant's term '*homotype*' might suitably be employed for any specimens that had been compared with the type, such specimens being, I believe, looked upon by entomologists with a respect which, in view of the difficulty of a proper comparison, mammalogists find a little hard to understand. But, as in other cases, if entomologists find the word useful, by all means let them use it, and let not those who don't want the word object to its use by those who do.

Lastly, may I express my pleasure at the advantage mammalogical nomenclature has gained by Mr. Palmer's critique* on my recent arrangement of rodents. Every zoological paper nowadays has two sides, a real and a nomenclatural, and it so happens that the nomenclatural side of the paper discussed is particularly susceptible of improvement, partly owing to the fact that the prospect of the appearance of Mr. Palmer's own list of mammalian genera made it obvious that any labor expended in this direction would be largely wasted, and partly because my own views of nomenclature underwent a radical change just as the paper was being printed, so that some names could be altered in accordance with the newer views, and others not.

To the omitted genus *Fiber*, *Dasymys* Peters† may be added, and may be placed at 43*a*, while *Nectomys*, also of the same author, should, as elsewhere pointed out, be restored to full rank, coming at 74*a*. It also proves that *Chiruromys* Thos., should give way to *Pogonomys* M. Edw.

* Merton Rules of Nomenclature, p. 13, 1896.

* Science, VI., p. 103, July 16, 1897.

† MB. AK. Berl., 1875, p. 12.

which, instead of being a synonym of *Uromys*, should take the former's place at 52.

One change which I myself pointed out in 1895, but forgot in 1896, has escaped the lynx eyes of Mr. Palmer, namely, that *Pygeretmus* Gloger* (1841) antedates and supersedes *Platycercomys* Brandt (1844), No. 117 of the list.

In what has been called the real part of the paper, I doubt if Mr. Palmer's criticisms on the suppression of the *Lophiomyidæ* and the separation of the *Spalacidæ* and *Bathyergidæ* would have been made had he ever compared the teeth—practically identical—of *Lophiomys* and *Cricetus cricetus*, or realized to what an extent similar fossorial habits may mask real differences by a superficial resemblance, so that the two families referred to, really incomparably more different in essentials than the Americen *Geomyidæ* and *Heteromyidæ*, have yet become so alike externally that zoologists of an earlier generation naturally thought them to be nearly allied.

But on these and other points further criticism is much to be desired, and I can only repeat how fortunate it is that my mistakes and omissions in the nomenclatural part of the paper should have had the advantage of revision by such an authority on the subject as Mr. Palmer.

OLDFIELD THOMAS.

MARRIAGE BY CAPTURE IN ARABIA.

Antar is a Bedouin romance reputed to have been written by Asmai, one of the learned men of the court of Haroun-al-Raschid, shortly before the beginning of the ninth century.† From the translation by Terrick Hamilton (London, 8vo., 1820), Vol. IV., pp. 388–9, the following description of an early Arabian marriage custom is quoted. The custom is a well known one. Asmai's explanation of it is new to me.

"Now, there was a certain curious custom current among the Arabs at that period. The night on which a bridegroom should wed his wife they brought a quantity of camel pack-saddles and heaped them one upon another, decorating them with magnificent garments. Here they conducted the bride, and having seated her on high, they said to the bridegroom, "Come on, now, for thy bride!" And the bridegroom rushed forward to carry her off, whilst the youths of the tribe, drawn up in line, right and left, with staves and stones in their hands, as soon as the bridegroom rushed forward, began beating and pelting him and doing their utmost to prevent his reaching his wife. If a rib or so were broken in the affair it was well for him; if he were killed it was his destiny.

"But should he reach his wife in safety, the people quitted him and no one attempted to approach him. ('I inquired about this circumstance,' says Asmai, 'and what it was they were about.' 'Asmai,' they answered, 'the meaning of this is to exhibit the bride to the warriors, that should her husband die, anyone else might take a fancy to her and take her off.')"

So far as my reading goes, the explanation of marriage by simulated capture, which is given in the last sentence, is entirely novel.

EDWARD S. HOLDEN.

LICK OBSERVATORY,
August 15, 1897.

*Naturgesch., p. 106.

† It is, in fact, a compilation of the XIIth century.

SCIENTIFIC LITERATURE.

The Foundations of Geometry. By B. A. W. RUSSELL. Cambridge: The University Press. 1897. Pp. xvi+201.

Here is a book especially opportune, on a subject of transcendent interest. The author's mathematical equipment is refreshingly sound, and his metaphysical results are delightfully suggestive, even where the mathematician may feel constrained to return as verdict 'not proven.' So much the more to be regretted is it that the Chapter I., 'A Short History of Metageometry,' should open with a glaring error, as follows: "The liquefaction of Euclidean orthodoxy is the axiom of parallels, and it was by the refusal to admit this axiom without proof that Metageometry began. The *first* effort in this direction, *that of Legendre*, was inspired by the hope of deducing this axiom from the others."

Mr. Russell cites Halsted's Bibliography of Hyper-Space and Non-Euclidean Geometry (1878), but can evidently never have seen it, since its first page speaks of 'The enormous

number of unsatisfactory attempts to prove this postulate,' and states that Sohncke gives a list of 92 authors on the subject before 1837, and that Perronet Thompson gave in English an account of like attempts before 1833, the very year our author cites for Legendre.

Mr. Russell goes on to say :

"Parallels are defined by Legendre as lines in the same plane, such that, if a third line cut them, it makes the sum of the interior and opposite angles equal to two right angles. He proves without difficulty that such lines would not meet."

But so had every school boy in the subject, since this is part of Euclid, Book I, Prop. 28:

"Similarly he can prove that the sum of the angles of a triangle cannot exceed two right angles, and that if any one triangle has a sum equal to two right angles all triangles have the same sum."

But these very demonstrations were published just a century before Mr. Russell's '*first* effort,' in 1733, by Saccheri.

Mr. Russell proceeds to speak of 'The originator of the whole system, Gauss,' and then says: "In 1799, writing to W. Bolyai, Gauss enunciates the important theorem that in hyperbolic geometry there is a maximum to the area of a triangle."

How utterly misleading, nay, fantastic, is this statement will appear on quoting the letter from 'Halsted's Science Absolute of Space,' 4th edition, Austin, 1896, which our author cites. Gauss says:

"I very much regret that I did not make use of our former proximity to find out *more* about your investigations in regard to the first grounds of geometry; I should certainly thereby have spared myself much vain labor, and would have become more restful than any one, such as I, can be, so long as on such a subject there yet remains so much to be wished for.

"In my own work thereon I myself have advanced far (though my other wholly heterogeneous employments leave me little time therefor), but *the* way, which I have hit upon, leads not so much to the goal which one wishes and which you assure me you have reached, as much more to making doubtful the truth of geometry.

"Indeed, I have come upon much, which with most no doubt would pass for a proof, but which in my eyes proves as good as NOTHING.

"For example, if one could prove that a rectilineal triangle is possible, whose content may be greater than any given surface, then I am in condition to prove with perfect rigor all geometry.

"Most would, indeed, let that pass as an axiom; I not; it might well be possible that, how far apart soever one took the three vertices of the triangle in space, yet the content was always under a given limit.

"I have more such theorems, but in none do I find anything satisfying."

From this letter it is perfectly clear that in 1799, so far from having the remotest idea of a hyperbolic geometry, or any non-Euclidean geometry, Gauss was still trying to prove that Euclid's is the only non-contradictory system of geometry and that it is the system of the external space of our physical experience. The first is false; the second can never be proved. But that both Gauss and W. Bolyai continued for the next five years to pound away in attempts to do the impossible, we have now obtained demonstrative evidence, in recovering a treatise finished and sent to Gauss by W. Bolyai in 1804.

In a great casket at Maros-Vásárhely all the unpublished papers of Bolyai János are preserved. All were placed freely at my disposal on my pilgrimage to this shrine of the non-Euclidean geometry. There, with extended researches anticipating the discoveries of Cayley and Klein in this subject, is an autobiography of János containing extracts from two letters written by Gauss to W. Bolyai (Farkas) and of transcendent importance as freeing János forever from the calumny again repeated by Mr. Russell where he says:

p. 12. "Gauss was, as we have seen, the inspirer of Wolfgang Bolyai. Wolfgang appears to have left to his son, Johann, the detailed working out of the hyperbolic system."

Nothing could be more false.

János, wholly unaided, discovered by himself the non-Euclidean geometry and taught it to Wolfgang, who transmitted it to Gauss. The two letters quoted by János are one before and one after this transmission.

This cry from the dead for tardy justice has since been shown exactly accurate by my friend, Fr. Schmidt, of Budapest, finding that the originals of these letters in the handwriting of Gauss still exist at Göttingen. The first is dated November 25, 1804, in answer to a letter

from W. Bolyai of September 16, 1804, accompanied by a Latin treatise, *Theoria parallelarum.*

It read as follows: "Now * * * yet somewhat about your geometric communication. I have read through your treatise with great interest and attention, and am right delighted at its really profound keenness. But you do not wish my empty praise, which also might seem in a measure partial because your train of ideas has very great resemblance to the way I formerly sought the untieing of this Gordian knot and vainly seek till now. You wish only my candid, open judgment. And this is, that your procedure does not give me satisfaction. I will seek, with as much clearness as I can, to bring to light the stone of stumbling which I still find therein (and which also again pertains to the same *group* of rocks wheron my attempts have hitherto been wrecked).

"I have indeed yet ever the hope that those rocks some day, and even before my end, will grant a thoroughfare. Meanwhile I have now so much other business on hand that I at present cannot think thereon, and, believe me, it will heartily delight me if you precede me and attain to overmaster all obstacles. I would, then, with inmost joy, do all in my power to make your service current and put it in the light.

* * * * * * * * *

Could you prove $dke = ekf = fkg$, etc., then would the thing be perfect. But this theorem is indeed true, only difficult to prove rigorously without already presupposing the theory of parallels. * *

You have my candid judgment. I have given it, and I repeat that it would genuinely delight me if you overcome all difficulties."

Here we see, with startling clearness, that in 1804 both Gauss and W. Bolyai (Bolyai Farkas) believe that Euclid's Parallel-Postulate can be proven, and indeed are racing to demonstrate it.

Before the next letter the unaided genius of the son, Bolyai János, has created the new universe, has found out all about it, mapped it, and proved Euclid's Postulate forever indemonstrable.

In transmitting in print to Gauss the immortal treatise of his son János, the most marvellous two dozen pages in the whole history of human thought, the father, Farkas, writes on June 20, 1831:

"My son is already First Lieutenant in the Engineering Corps, and will soon be Captain, a handsome youth, a virtuoso on the violin, a fine fencer and brave, but has often dueled, and is still altogether too wild a soldier—but also very refined—light in darkness and darkness in light, and an impassioned mathematician with very rare gifts of mind. At present he is in the garrison at Lemberg—a great admirer of you—capable of understanding and appreciating you. At his desire, I send you this little work of his. Have the goodness to judge it with your sharp, penetrating eye, and to write your high judgment unsparingly in your answer, which I ardently await. It is the first beginning of my work, which is under the press. I would gladly send with this the first volume, but it is not yet out.

"According to my view, is in the work of my son, u (namely, where a first does not cut the b) geometrically constructed; whence, however, is not determined how great u is, from O on up to R (that excluded, this included).

"Yet everything in geometry is either dependent on u or not; (*e. g.*) spherical trigonometry is in § 26 settled as independent of it. * * *

"At the end he also shows that if u not $= R$, then the circle can be squared."

Thus we see that the treatise sent to Gauss on June 20, 1831, was the immortal Appendix just as published. The Gordian knot, at which Gauss himself had for years tried in vain, was here forever gloriously untied.

After waiting six months the anxious father tries again, and on January 16, 1832, once more sends Gauss the work of János, saying in the accompanying letter:

"My son was not present when his little work was printed. He had printed the errata (which follow); in order to be less burdensome to you, I have corrected the most with a pen.

"He writes from Lemberg that he has since simplified and made more elegant many things, and has proven the impossibility of determining *a priori* whether Axiom XI be true or not."

To this, on March 6, 1832, comes from Gauss at length an answer as follows:

* * * "Now somewhat about the work of your son:

"If I thus begin 'that I dare not praise it' you will a moment wonder; but I cannot otherwise; to praise it would mean to praise myself. For the whole content of the book, the way your son has hit out and the results to which he is led, are identical almost throughout with my own meditations, made in part already 30–35 years ago. In fact, I am thereby extremely delighted. My intention was to let nothing be known during my lifetime of my own work, of which moreover until now little has been put on paper. Most men have not at all the right sense for

what is here in question, and I have found only few people who received with special interest that which I communicated to them. In order for that one must first have felt right keenly what really is lacking, and about that most men are wholly indistinct.

"On the other hand, my intention was, with time, to put all on paper, so that it at least would not hereafter perish with me.

"Therefore am I greatly pleased that this trouble can now be spared me, and it is most highly delightful to me that the son of just my old friend is he who in so remarkable a way has anticipated me.

"I find his notations very pregnant and abridging. Yet I believe it would be good to establish for many chief ideas not merely symbols or letters, but definite names, and I have already since long thought of some such names.

"So long as one thinks through the thing only in immediate intuition, one needs no name or symbol; these are first necessary, if one wishes to be comprehensible to others. So, for example, the surface which your son calls F could be called a Parasphere, the line L a Paracykle: they are, in fact, spheres or circles of infinite radius. Hypercykle could be named the complex of all points which have like distance from a straight with which they lie in a plane; even so Hypersphere. Yet those are all only unimportant incidents; the main thing is the matter, not the form.

* * * * * *

"Just exactly in the impossibility to decide *a priori* between Σ and S lies the clearest proof that Kant was wrong to maintain, Space is *only Form* of our intuition."

About the other independent discoverer of the non-Euclidean geometry, Lobachévski, Gauss writes to Schumacher, November 28, 1846, without a word of reference to Bolyai, as follows:

"I have lately had occasion to reread the opuscule of Lobatschewsky, intitled: *Geometrische Untersuchungen zur Theorie der Parallellinien*. This opuscle contains the elements of the geometry which would exist and development of which would form a rigorous chain, if the *Euclidean* geometry were not true. * * * You know that since fifty-four years (since 1792) I share the same convictions, without speaking here of certain developments which my ideas on this subject have since received. Therefore, I have not found in the work of Lobachevski any fact new to me; but the exposition is wholly different from that which I had projected, and the author has treated the matter with a master hand and with the veritable geometric spirit."

How reconcile these letters with that of 1804? And since one says that Bolyai's exposition is identical with that of Gauss, while the other declares Lobachévski's wholly different from that, how reconcile them with the statement of Mr. Russell, p. 11: "Very similar [to Lobachévski's] is the system of *Johann Bolyai*, so similar, indeed, as to make the independence of the two works, though a well-authenticated fact, seem all but incredible?"

This letter of 1846 shows no hint of that other sort of non-Euclidean geometry which Riemann gave in his wonderful Probevorlesung, 'Ueber die Hypothesen welche der Geometrie zu Grunde liegen,' June 10, 1854.

But this dissertation was not published until 1867, so that the waters of oblivion seemed to close over it as over the works of Bolyai and Lobachévski.

Mr. Russell should not have omitted in his text all mention of Hoüel, for Hoüel it was who resurrected the non-Euclidean geometry, beginning with his own essay on the fundamental principles of geometry, published in 1863 at Greifswald. (See his life in the *Amer. Math. Monthly*, April, 1897.)

But not to give too much space to actual slips in history we must jump to the second of Mr. Russell's four chapters, 'Critical account of some previous philosophical theories of geometry:'

"The importance of geometry in the theories of knowledge which have arisen in the past can scarcely be exaggerated."

The author believes that the usual forms of non-Euclidean geometry, the hyperbolic, the double elliptic and the single elliptic are the only logically self-consistent systems, and so says: "I shall contend that those axioms, which Euclid and Metageometry have in common, coincide with those properties of any form of externality which are deducible, by the principle of contradiction, from the possibility of experience of an external world."

We see at once that pure projective geometry must be of supreme weight for him.

It is a treat to see our author overwhelm the apparent subordination of the non-Euclidean spaces by the introduction of different measures of distance. This was the painful mistake of

Emory McClintock in his article 'On the non-Euclidean geometry' in the Bulletin of the N. Y. (Amer.) Math. Soc., Vol. II., pp. 21–33, which reached the pitiful conclusion (p. 32): "The chief lesson to be obtained from all non-euclidian diversions (sic) is that the distinguishing mark of euclidian geometry is fixity of distance—measurement."

Mr. Russell, with equal deftness, puts in pillory the gross blunder made by Andrew W. Phillips and Irving Fisher, professors in Yale University, in the note on p. 23 of their Elements of Geometry, where they say: "Lobatchewsky in 1829 proved that we can never get rid of the parallel axiom without assuming the space in which we live to be very different from *what we know it to be through experience.*"

By experience, of course, we can never know or prove our space to be other than a non-Euclidean space with a comparatively large constant. How unexpected, then, the error of Professor H. Schubert, of Hamburg, in the *Monist*, Vol. VI., No. 2, p. 295, where he says:

"Let me recall the controversy which has been waged in this century regarding the eleventh axiom of Euclid, that only one line can be drawn through a point parallel to another straight line. The discussion merely touched the question whether the axiom was capable of demonstration solely by means of the other propositions, or whether it was not a special property, *apprehensible only by sense-experience*, of that space of three dimensions in which the organic world has been produced."

After 20 years' study of writers on the non-Euclidean geometry, the present reviewer cannot recall even one who was ever silly enough to think that the exact equality of the angle-sum of a rectilineal triangle to two right angles was apprehensible by sense-experience, or could ever be known through experience.

This new Yale geometry also makes the old *petitio principii* of defining a straight line as the *shortest* distance between two points. This our author treats in his third chapter, p. 167:

"We are accustomed to the definition of the straight line as the *shortest* distance between two points. * * * Unless we presuppose the straight line, we have no means of comparing the lengths of different curves and can, therefore, never discover the applicability of our definition."

In projective geometry any two points uniquely determine a line, *the straight*. But any two points and their straight are, in pure projective geometry, utterly indistinguishable from any other point-pair and their straight. It is of the essence of metric geometry that two points shall completely determine a spatial quantity, *the sect*. If our author had used for this fundamental spatial magnitude this name, introduced in 1881, his exposition would have gained wonderfully in clearness.

Both the accepted popular and the accepted mathematical definition of 'distance' make it always a number, as, *e. g.*, the Cayley-Klein definition: "The distance between two points is equal to a constant times the logarithm of the cross ratio in which the line joining the two points is divided by the fundamental quadric."

It is the misfortune of our author to use the already overworked and often misused word 'distance' as a confounding and confusing designation for a sect itself and also the measures of that sect, whether by superposition, ordinary ratio, indeterminate as depending on the choice of a unit, or projective metrics, indeterminate as depending on the fixing of the two points to be taken as constant in the varying cross ratios.

This whole book might be cited as an overwhelming vindication of the only American treatise on Projective Geometry against the attack on it made by a critic in SCIENCE, because, forsooth, it was founded and developed as *pure* projective geometry, without any quantitative ideas whatever.

Into the fourth and last chapter, 'Philosophical Consequences,' we will not here go. Suffice it to say that Projective and Metric Geometry, though eternally separate in essence, and each unable ever to absorb the other, are happily wedded, and expand joyfully ever after.

GEORGE BRUCE HALSTED.

AUSTIN, TEXAS.

Sight: An Exposition of the Principles of Monocular and Binocular Vision. JOSEPH LE CONTE. New York, D. Appleton & Co. 1897. Second edition, revised and enlarged. Pp. xvi + 318. $1.50.

A revised and enlarged edition of Professor

Le Conte's book on 'Sight' is extremely welcome. It remains true now, as it was in 1880, when the first edition was published, that there is no other book in the English language covering this field. During the past year two excellent American contributions have, indeed, been made to the subject—Professor Bowditch's survey in the 'American Text-book of Physiology' and the various articles in the 'Systems of Diseases of the Eye,' by Norris and Oliver. But Professor Le Conte's book is the only treatise covering the subject of vision in English, and, in fact, in any language, with the exception of the more technical works of von Helmholtz and Aubert. While it is surprising, and not altogether creditable to the 'new psychology,' that we have only one book on the subject, it is fortunate that it is so excellent.

Professor Le Conte devotes two-thirds of his book to binocular vision. This is excessive for a text-book, but it is justified by the interest of the subject and by the important original contributions of the author. Following an introduction on the senses, the part on monocular vision includes sections on the general structure of the eye, the formation of the image, the perfect eye, defects of the eye, structure of the retina, space perception and color perception. In this part should, perhaps, be included the final chapter on the evolution of the eye, added in this edition, which, however, appears as the 7th chapter of the third part, entitled in the table of contents, 'Some abstruser points, especially in binocular vision,' and in the text, 'On some disputed points in binocular vision.'

The author has added some new matter to this first part, especially on color blindness and color perception, including a full statement of the Donders-Franklin theory. I regret the omission or brief treatment of subjects so important as the intensity of sensations, their time relations, the field of vision, illusions, the combination of colors,* etc. It is in any case evident that everything cannot be included in 100 pages, and it is a wonder that Professor Le Conte has been able to give with such clearness so much. There are several points on which I should differ with the author. For example, the explanation of 'upright vision,' which has been discussed in this JOURNAL. Professor Stratton, a colleague of Professor Le Conte's at the University of California, has since made the ingenious experiment of wearing, for several days, glasses that inverted the normal retinal image and shows how quickly adjustment is made. But it is still easier to stand on one's head and notice that the landscape is not seen inverted.

The two parts on binocular vision contain clear and concise accounts of experiments largely devised by Professor Le Conte. Making these experiments would, as the author says, be for any one an admirable culture in scientific method. Many of the experiments are valuable contributions to science, but the details are somewhat complex and cannot be made clear in a review. The reader must turn to Professor Le Conte's book, with its many new and ingenious illustrations, in order to appreciate the importance of a study of binocular vision and the great value of the author's contributions to the subject. I may note that I have recently been told by an eminent oculist that the conflicting results in the case of Listing's law found by von Helmholtz were due to unrecognized astigmatism in his eyes.

There are some points where Professor Le Conte's statements do not seem to me quite accurate. For example, he says, "We always see things double, except under certain conditions." This is scarcely correct psychology; we must learn by practice to see things double, and then usually see them double only while the experiment lasts. Professor Le Conte says, "I believe that the existence of the central spot is necessary to fixed, *thoughtful attention*, and this, again, in its turn, is necessary for the development of the higher faculties of the mind." But may not the mental faculties of those born blind be developed? There are further many subjects, such as the horopter, that I cannot regard as finally solved by Professor Le Conte, but his researches have accomplished much toward their solution and should be accepted as the basis of future work.

J. McKEEN CATTELL.

COLUMBIA UNIVERSITY.

*Fortunately some of these topics are fully treated in another admirable book in this same series, Professor Rood's 'Modern Chromatics.'